THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XXXI.—*A brief Memoir of the late Walter Folger, of Nantucket;* by WILLIAM MITCHELL.

AMONG men of genius, those who have shared largely of nature's gifts, and manifested a high order of intellect in reference to those inquiries which are hidden from ordinary minds, the late Walter Folger of Nantucket, is entitled to a prominent rank. He was born in the 6th month, (June,) 1765. His father, also named Walter, was among the wealthier class of that day, and one of the first who engaged in the manufacture of sperm candles, since become so extensively the business of the place. He was descended from Peter Folger, one of the earlier settlers of the island, the maternal grandfather of Franklin, and the poet whose memory the Doctor so fondly cherished. Walter, senior, was much distinguished in early life for mechanical and mathematical talent, and at a later period when withdrawn from business, though eclipsed in every department by his son, he was sure to be found wherever any mechanical operation was in progress, that involved novelty of art or excellence of execution. On his mother's side the subject of this memoir was descended directly from Mary Starbuck, a matron of great notoriety in the history of the island; the first convert to the principles of the society of Friends, and the minister by whose influence so large a portion of those isolated people became members of that body of professing christians. Of this distinguished lady, we find an account in the journal of a traveling minister of the society, who visited the island in the early part of the last century. "There was," says he, "on the island, one Nathaniel Starbuck, whose wife was a wise discreet

woman, well read in scripture and not attached to any sect; but in great reputation throughout the island for knowledge in matters of religion, and an oracle among them on that account, insomuch that they would not do any thing without her advice and consent therein."

Although his family were numerous, the means of the father were quite adequate to furnish his son with liberal instruction; but education in that day, was but lightly esteemed by the islanders, a state of things forming a striking contrast with the agreeable circumstances of the present day, and his youth, with the exception of a few weeks occasionally spent in very indifferent schools, mostly taught by females, was suffered to pass away without that instruction which, with such materials to work upon, would have been of so much value to science.

In these schools he soon comprehended all that was taught, and spent most of his time in alternately assisting the pupils and instructing the teachers. The first study, in those branches in which he became distinguished, to which he directed his attention, was that of land surveying, in which, without the least personal assistance, he became exceedingly skillful. In the winter of 1782–3, he attended an evening school, in which he studied navigation and gauging, and readily acquainted himself with these branches. Nothing of a mathematical character seemed ever to present any difficulty to his mind. He mastered Algebra and Fluxions, without assistance, and while in his teens he read Euclid, as he would read a narrative, no problem arresting his progress; and yet so little did he know of language, or of any thing appertaining to it, that he had reached the years of manhood, as he often confessed, before he knew the definition of the word *grammar*. He afterwards accidentally met with an old volume of La Lande's large astronomical work, in the hands of a castaway sailor and purchased it, and to enable him to read it, he studied the French language, and with it the English, and was therefore able to read the French authors with ease. From this time he applied himself with great assiduity to the principal departments of physical science. As a practical mechanic and optician, he had few superiors, and in his own town certainly no equal. Every species of machinery on which he placed his eye, he seemed at once to comprehend. During most of the year 1783, he was afflicted with ill health, and much of the time confined to his bed begging constantly for books, which seemed the only needful opiate. There were few books at hand adapted to his taste; but his father finally succeeded in obtaining for him a work on Navigation, to which for the first time, was appended Dr. Maskelyne's method of obtaining the longitude at sea by means of lunar distances. This delighted him, and at the age of eighteen, prostrated with sickness, he familiarized himself with

the problem, and the engagement so diverted his mind from his infirmities that he speedily regained his strength. He immediately applied all his influence to the encouragement of the use of this method among his fellow-townsmen, then universally engaged in the prosecution of whaling voyages. To numbers he gave personal instruction, and the first American ship-master who determined his longitude by lunar observations, is said to have been one of his pupils.

Soon after this period, he busied his mind in designing a clock, which, while answering the ordinary purposes of time-keeping, should exhibit various phenomena connected with the solar and lunar motions. Having completed the plan, he submitted it to his father, for whose judgment in mechanics he had the highest regard, and receiving his sanction, he commenced the work at the age of twenty-two, and devoting only his leisure amid other engagements, finished it in the course of the second year. This clock now stands in the family parlor a monument of mechanical ingenuity;—brown with age and now somewhat antiquated in its appearance, it is still a wonder. Nothing but the glass which covers its face, owes its construction to another hand, and its mechanical execution would be creditable to a professed workman. But its chief excellence is in the phenomena which it exhibits. The diurnal motion of the sun is represented by a circular metallic plate, so adjusted that it is seen through a slit in the dial plate, at a greater or less meridian altitude, as the declination changes; rising and setting as in nature, and changing the time in conformity to the latitude, change of declination and equation on each day, giving also through the entire day, the time of his rising and setting and place in the ecliptic. The moon is represented by a spherule exhibited to the eye in the same manner; but by having one hemisphere colored, and by a process much more complicated, shows with great faithfulness, not only the rising, setting and southing of the moon, with the time of full sea at Nantucket; but also the chief phenomena dependent on the obliquity of the moon's path to the ecliptic, and the revolution of her nodes, such as the hunter's and harvest moon, &c. Some of these involve a motion of the works through a period of eighteen years and two hundred and twenty-five days, and the wheel by which the date of the year is advertised is so constructed, that its revolution is only completed in one hundred years, though necessarily suspended ten years of that period.

For the year 1790, he made the necessary calculations and published an almanac; he had prepared also the ephemeris of 1791, with some very curious calculations on the annular eclipse of that year, the formation of the ring occurring precisely at sunrise; but these he never published.

In concert with several observers on the continent, among whom were Bowditch and Jefferson, he made special preparation, to observe the beginning and end of the solar eclipse of 1806, total in Boston and nearly so at Nantucket. The day was cloudless and the results satisfactory.

Probably the most valuable observations that he ever made were those on the comet of 1807—the first comet he had ever seen. On the first appearance of this body, he commenced taking a series of angular distances to the various fixed stars near which it passed. Then angles were taken with a sextant, in the use of which he was very skillful. Having been in the habit for many years of adjusting this instrument for the seamen of his native town, no one could use it more dexterously. His application to this work, as to every undertaking, was unremitting; he followed it through the whole period of its visibility, and in the latter part of autumn, while the comet was circumpolar, by obtaining angles through the whole night above and below the pole, he was able to detect its parallax, as well as its motion and position.

These observations were never published, and it now may be well doubted whether a vestige of his notes remain, the labor having been performed chiefly for his own gratification. The great comet of 1811 did not escape his attention, and his observations met with a better fate. He was induced to publish them in detail, and they were so numerous that the angles alone, when reduced, occupied an entire page of a Boston newspaper. With his expertness in the use of the sextant, and the sharp nucleus of that beautiful comet, his results were exceedingly accurate, and were so esteemed by Dr. Bowditch who used them in calculating its elements.

In earlier life he had constructed a number of small telescopes; but at the age of fifty-four he undertook the construction of a reflector of considerable size, and finished it in the succeeding year. This telescope is a Gregorian, the larger speculum is five inches, and the smaller, one inch in diameter. Its focal length is five feet, with one eye-piece magnifying not less than three hundred. It is not mounted equatorially, nor has it any arrangement for measures; but it is furnished with rack work for slow azimuth and altitude movement. The stand is of oak and has four legs on the plan recommended by the elder Tulley, and it is exceedingly steady—illustrating the advantage of this method for firmness no less than safety. The tube is of sheet iron and very neatly finished. The stand, which was made by his son, is the only part which was not formed by his own hands. In grinding the large speculum he dispensed entirely with the bed of hones, using the grinding powder after it was worn very fine on the pewter tool. In reference to its figure, there is doubt whether its curve is parabolic. He objected to that form and demonstrated that it is not

the best except for objects whose distance is infinite. When the specula were finished, they were placed for trial in a rude tube of deal board mounted on a temporary support and directed to the planet Jupiter; and whatever may have been its subsequent performances, which were certainly no better than what might have been anticipated,—in this first trial its performance was astonishing. For light, distinctness of vision, and clearness of outline, it is scarcely surpassed by the larger and far more expensive instruments of the present day. While in this tube and with this temporary adjustment, he viewed the moon under favorable circumstances of weather, three days after the change, and detected that delicate thread of corpuscular light which was seen by Schröter in the early part of the year 1792 with a reflector of nearly the same size, and he described it almost in the words of the German astronomer, though he had never seen the paper of Schröter and knew nothing of the discovery. When the telescope was completed and mounted, his neighbors thronged his house to obtain a sight of the moon or other celestial objects, and although a severe tax upon him, he at all times gratified their wishes with the most enduring patience.

On the occasion of the return of the Encke comet in 1829, when the theory of Encke was so strikingly verified, he became interested in the subject of a resisting medium, and for his own satisfaction constructed a set of tables for the determination of the place of the comet for any period past or future within the limit of a thousand years. The labor in the construction of these tables was immense; but with his usual untiring zeal and application, he accomplished it, before the comet was beyond the reach of the telescope. The figures made in this work were so numerous that he often exhibited the sheets containing the rough computations as a curiosity. These tables he always declined publishing though often solicited to do so, and they remain to this day among the fragments of his industry.

He kept for many years a meteorological journal, using a barometer and thermometer of his own construction, both of which were remarkable for their accuracy. Indeed he was never satisfied with the use of any instruments unless he was entirely confident of their utmost accuracy, and to be certain of this, he was compelled to form them with his own hand. In the prosecution of his meteorological inquiries he convinced himself of the truth of the gyratory theory of Redfield and defended it with energy. In the more vigorous period of his life, he was a contributor to the mathematical periodicals of the day, solving the more difficult problems and proposing others. Among his correspondents in science, were Doctors Bowditch, Prince and Oliver, and President Jefferson.

Having at different periods engaged in the study of the law and acted some years as an attorney, he received the appointment of judge of the county court, and so far as a profound regard to justice is concerned, no appointment could have been more judicious. He knew nothing of dissimulation; nothing could influence him from the straightest line of uprightness. In his morals and in his dealings with men, he seemed to know nothing but the exactness of his mathematics.

He interested himself also in the politics of the day; was a member of the legislature of his native state several years during the period of the most rabid party divisions. As in science so in politics, he was a friend of Jefferson, and belonged to the old democratic party, and was twice elected to Congress. While at Washington he was not unmindful of his favorite themes, and it was proverbial among his colleagues, that in the recess of the sittings or when his seat was vacant, he could always be found at the Patent Office.

While his conscientiousness was a sufficient guaranty that no item of duty would for a moment, under any circumstances, be neglected, we are not among those who believe that the square and dividers are adapted to political purposes, however desirable a measure of the exact may be in the government of men and policy of the state; and the history of La Place is not the only comment upon this philosophy.

In the most laborious investigations, his patience was without limit. Nothing seemed capable of diverting him from his purpose, nor were the wants of his life deemed of any consequence to him when engaged in the solution of a mechanical or mathematical problem. Time was no object to him either in the prosecution of his own inquiries, or in imparting knowledge to his less learned neighbors and townsmen. But the object of this memoir is rather to commemorate the genius and acquirements of Folger than to comment upon his moral qualities. In reference to the latter, however, much might be said of his rigid virtues and abstemious habits; and although like Count Rumford he seemed at times soured and disappointed that men did not conduct themselves more in conformity with his own exact views, yet it was easy amid all this to perceive traces of good and benevolent impulses. He died on the 8th of the 9th month, 1849, at the age of 84.

ART. XXXII.—*On the Application of Photography to the Self-registration of Magnetical and Meteorological Instruments;* by Captain J. H. LEFROY, R.A., F.R.S., Director H. M. Magnetical and Meteorological Observatory at Toronto, Canada.

THE successful application of the principle of self-registration by means of the action of light upon sensitive paper, or upon silvered plates, to observations in magnetism and meteorology, may be instanced as one of the most important indirect results of the great stimulus given to such inquiries by the encouragement and support extended to them for the last ten years by the governments of Great Britain, of Russia, and of various other countries, by the augmented attention of scientific bodies, and in short, by the more general recognition of their claim to an honorable place among the pursuits of science. Nor is it easy to foresee the full extent to which this principle may be destined in the end to supersede the tedious processes of personal observation, or the imperfect ones of delineation and description. In terrestrial magnetism, more particularly, it has been brought to perfection at a peculiarly appropriate time. From eight to ten years of laborious observations, have accumulated, probably, almost every thing that is essential for determining the numerical elements of its different periodical laws, and for a comparison of their operation in distant parts of the globe; but in spite of these observations, hourly, or two-hourly, by day and night, in spite of special observations upon all magnetical disturbances detected, and of term days designed to detect them but on which they seem to have made it a point not to occur; in spite of the extraordinary patience of Colonel Boileau in observing at Simla, not every hour, but every fifteen minutes, and of the perseverance with which Dr. Bache, at Philadelphia, multiplied his observations at the critical hours of each of the elements, in spite, in short, of all the efforts which have been made to obtain a full knowledge of the fluctuations of these most inconstant objects, it cannot be doubted that by far the greater, and perhaps the more instructive portion of all their changes, eluded the vigilance of the observers. In this state of things, therefore, a method which secures a minute and continuous graphical record of every change, and which can be put in practice with comparatively little difficulty or expense, is an acquisition to the science, second perhaps only to the invention by Gauss and Lloyd of the instrumental means upon which its previous rapid progress has been so largely based. The following description of the Photographical Instrument of Mr. Brooke, is based principally upon that gentleman's communi-

cation to the Royal Society in 1847,* and the advice and instructions with which the writer has been favored by him from time to time, in the establishment of one at Toronto. The various changes in detail which have been suggested by experience since the date of the paper referred to, and the possibility that the present communication may promote the establishment of other registers on this continent, will afford, it is hoped, a sufficient apology for its want of originality.

"In order to render any method of photographic registration practically useful, it is essential that the three following indications should be fulfilled.

"First, to obtain an easily managed artificial light of sufficient intensity to affect photographic paper, especially at those periods when it is of most consequence to obtain a continuous register, namely, when the position of the magnet is undergoing great and rapid variations.

"Secondly, to prepare by a ready process a photographic paper sufficiently sensitive to receive the feeble impressions of artificial light, and at the same time sufficiently durable to retain those impressions during a period of at least twelve hours, as a more frequent attention to the apparatus would probably interfere with the ordinary arrangements of an observatory.

"Thirdly, to magnify the movements of the magnet by some optical arrangement, so that the variations may be indicated with sufficient minuteness and accuracy."

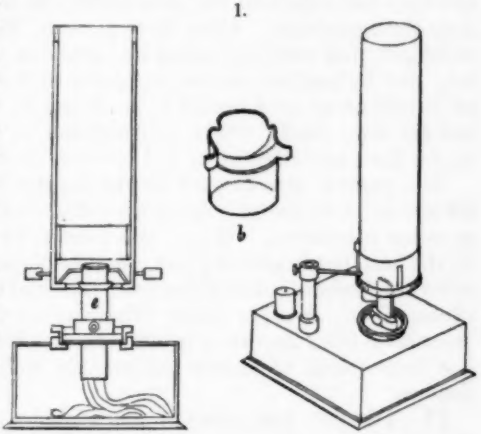
The union of the three conditions is represented by a suspended magnet carrying a metallic reflector, by which a ray of light from a fixed lamp is thrown on the surface of a sheet of prepared paper, rolled round a glass cylinder, and made to revolve by a time piece.

The first of them, namely, that which relates to the light, was in the experiments of the first two or three years, attained by the employment of a camphine lamp. Mr. Brooke has recently succeeded in producing traces by the light of an oil lamp, which, although somewhat more expensive, is free from the inconveniences apt to attend the use of camphine. The camphine lamps, however, being still in use at Toronto, I proceed to describe them. The form of the lamp is square, two and a half inches on the side, one and a half deep; each contains about a quarter of a pint of the fluid, and is calculated, with *perfectly good camphine*, to burn twelve hours without requiring attention—in general it will be necessary to attend to it every six hours, by cutting off the charred end of the wick and refilling. A circular opening about 1·2 inch in diameter is made at the top near the centre of the side which is presented in front, this is stopped with a bone or

* "Description of an apparatus for the Automatic Registration of Magnetometers and other Meteorological Instruments by Photography." By Charles Brooke, M.B., F.R.S., &c. Philos. Trans., 1847.

ivory disk, and through the latter passes, by a narrow cut, made for the purpose, the burner or support for the wick, which is flat, half an inch wide and one-eighth of an inch in thickness. Common ball cotton may be used for the wick, by drawing as many lengths through the burner as fill it closely, but not tightly. A movable ring or collar with a set screw, allows the burner to be fixed at any required height, while, the stopper being movable, it can also be turned to form any required angle with the face of the lamp. Let us then suppose the lamp to be placed behind a screen containing a narrow vertical slit through which the light is to pass, and to slide in a groove so as to be always presented in precisely the same position; let us suppose also the screen in question to be fixed to the stand which supports the lamp. To begin, then, with the regulation of the light, the burner is first to be fixed at such a height that the top of the wick shall be exactly level with the bottom of the slit; it is then to be turned in azimuth so as to be presented edgewise at an angle of about 80° with the screen, or at such an angle as to give a cone of rays very slightly wider than the mirror. The support of the chimney of the lamp is then to be applied, and its height regulated so that the diaphragm by which the combustion is promoted, shall be about 0·10 inch below the top of the wick. Lastly, the chimney is added to the support, and the adjustments of the lamp are completed by applying the short cylindrical shade which fits under the legs of the chimney, and prevents all lateral diffusion of the light. The employment of camphine, although desirable on grounds of economy, as well as for the brilliancy and whiteness of its light, is attended with serious inconveniences. The fluid deteriorates very rapidly at summer temperatures 'by the absorption of oxygen, which converts a portion of the camphine into resin, which is held in solution in the remainder, and is deposited on the wick,' in fact it becomes perfectly useless; unless, therefore,

1.



a. Lamps and chimney.—*b*. Ring placed under the chimney to cut off strong light.—*c*. Section of lamps, shewing the burner (*e*) and the diaphragm in the chimney.

the position of the observer enables him to procure constantly, fresh supplies of newly distilled fluid, he must expect trouble from this source. It has more than once happened that the resin about the wick and surface of the lamp has conducted the flame to the whole body of the camphine, which then burns with violence, but this ought not to occur if the lamp is *kept clean;* a more common inconvenience is its smoking, which occurs when the wick is too long, or the burner too high or too low relatively to the fixed diaphragm; great nicety is required in these points; but with bad camphine the utmost care can scarcely give security from the annoyance. Upon these grounds, Mr. Brooke, as already remarked, has recently turned his attention to devising a substitute, and by heightening the sensibility of the paper, has succeeded in producing good results with oil lamps. Gas, it is believed, has not been tried; where at command, it will probably prove by far the most convenient and effectual source of light.

The paper at present used for the register is prepared expressly for the purpose, the pulp being carefully freed from acid, alkaline, or saline substances. Where this cannot be procured, it should be the best highly glazed paper, not recently made, of the ordinary letter size before doubling, free from lime and other impurities, and of fine fibre. A paper called Whatman's yellow wove folio post procurable from importers in Canada, and bearing the date 1842, has been found to answer remarkably well. It is prepared as follows.

(1.) Dissolve five grains of fine isinglass in one fluid ounce of *distilled* water; the water should be poured boiling on the isinglass, and then set before the fire, and stirred occasionally until the latter is dissolved; perhaps this will require ten or fifteen minutes. As a portion is lost by evaporation, and afterwards in filtering, it is convenient to increase the quantity of both by one half, that is, to take an ounce and a half of water, and seven or eight grains of isinglass: while this is dissolving, weigh out twelve grains of the bromid and eight of the iodid of potassium, put both salts into a deep glass, such as a large wine glass. Extreme nicety in the quantities is not required, the effects having been produced with proportions varying from ten to sixteen grains of the bromid, and from two to eight grains of the iodid. The isinglass being sufficiently dissolved, filter one fluid ounce in quantity on the salts, through white blotting paper or filtering paper. The salts may be stirred with a glass stick, and the solution then set aside until cold.

The paper for a register of one element is cut lengthwise into slips of half the width of the sheet, each being about fifteen inches long, by four and three-quarters wide: if two elements are registered together, the undivided sheet is used. Having marked one side, for distinction secure the paper, with the unmarked side upwards, by a pin at each corner, to a clear pine

board, rather larger than itself, and with a soft wide camel's hair brush kept exclusively for this purpose, apply the above solution uniformly and somewhat sparingly to its surface, taking care not to leave on it enough to run when the board is held to the fire, in which case yellow stains will be produced in consequence of a determination of the sulphuret of silver to parts which were too much wetted. Hold the paper on the board promptly to the fire so as to dry the solution uniformly and rapidly, and leave the salts very much on the surface; care must be taken not to scorch the paper. In brushing the paper, in this, as in all subsequent processes, it is well to take pains not to allow any of it to run over the edge, to the reverse side, where it leaves unsightly stains. Paper thus prepared, is not affected by light, and will keep a considerable length of time, but as it performs best when fresh, the inventor recommends the preparation of only a week's supply at once. An ounce of solution is sufficient for twelve or fifteen slips; on one occasion a paper of three months old at Toronto, yielded a good curve, but in general they present neutral patches to a greater or less extent, if kept too long.

The next step is to render the paper sensitive. For this purpose, prepare another slip of wood; secure a slip of the prepared paper to this, in the same way as before; exclude daylight, and make use of a lantern glazed with red or yellow glass, then pour into a capsule about a teaspoonfull of the following solution.

(2.) Dissolve fifty grains of nitrate of silver in one ounce of distilled water; apply it to the paper lightly and carefully, brushing first longitudinally, then across; it is scarcely necessary to say that each solution must have its own brush, its own cup, and even its own cloth for drying the cup and brush.* The paper being uniformly wetted, roll it immediately round the glass cylinder, which must be previously wiped dry, and secure it, where the ends overlap, by a little gum dissolved in acetic acid. If but one lamp is used, it is necessary to make a couple of pencil marks across the junction of the folds, to furnish a base line. The light being then allowed to fall on the paper at any chosen moment of time, the trace commences. The above directions apply to the ordinary process when camphine is used; to give the paper the additional sensibility required with an oil lamp, Mr. Brooke directs to rinse the paper in water after applying the nitrate of silver, holding it by the two ends and shaking it a little, under the surface of the water in the dish. It is then to be laid on a cloth, and the water pressed out of it, by passing a glass rod or piece of tube two or three times over it, with gentle pressure. (To avoid the contact of organic matter with the prepared surface.) About half a teaspoonful of the nitrate of silver solution is then poured on the paper,

* A small covered box having a place for each cup, each bottle, and each brush, will be found convenient. The cups should be further distinguishable by some difference of shape or color, and the brushes marked.

and the glass rod again passed lightly over it, which diffuses the solution over it; after which it is applied to the cylinder as before; by this process the sensibility of the paper is said to be much increased, and it keeps a cleaner surface. To present at one view the different chemical processes, we will suppose the cylinder to be now left to complete one revolution (of twelve hours) or two, as the case may be, the paper has then to be removed, the impression to be developed, and then fixed. For this purpose a common large dish is required, which should be placed before a fire until moderately warm. Excluding daylight as before, remove the cylinder carefully from its supports, take off the paper with as little fingering as possible, and lay it on the dish; no indication of the trace will be perceived, unless the disk be more than duly heated, in this case the lines sometimes appear faintly without farther treatment, but the paper darkens too much afterwards. It has to be now brushed with

(3.) Twenty grains of crystallized gallic acid, dissolved in one ounce of distilled water* when it appears in a minute or two. When the impression is sufficiently distinct, which will generally be in the space of five minutes, the gallic acid must be washed off by repeated sluicings with soft water, assisted by a soft brush. In a cold place, or with a cold dish, a longer time is required; in short the whole process seems to succeed best, like most photographic processes, at a high temperature, although the trace has been developed at a temperature low enough to convert the solution into a film of ice. When the uncombined nitrate of silver and gallic acid are thoroughly washed off, the light may be admitted without danger; it then remains to fix the impression by transferring the paper to a clean dish or board, and brushing it with about one table spoonful of the usual solution, namely,

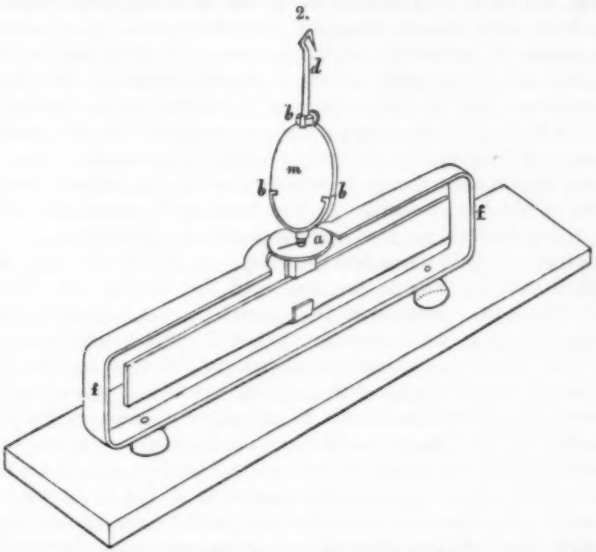
(4.) Twelve grains of hyposulphite of soda to one ounce of distilled water. It will be observed that rather a larger quantity of this solution is laid on the paper than of the previous ones. If an insufficient quantity be applied, or it be not uniformly distributed, the paper is apt to acquire a dirty brown stain, in patches, passing into black, which latter it ultimately becomes when no hyposulphite is applied; in this case, the margin of the previously dark lines becomes the lightest portion; after allowing the hyposulphite a few minutes to act, it must be thoroughly washed off, by repeated sluicings of water, assisted as before, with a soft brush, otherwise it enters into a new combination which spoils the specimen: the paper may then be placed between the folds of clean white blotting paper until dry, when the process is completed.

We may now return to the mechanical details. The magnet employed is about two feet long, one inch and a quarter

* One ounce of water will not hold twenty grains of gallic acid in solution at ordinary temperatures; it is necessary to dip the bottle in boiling water, or heat a small portion of surcharged solution, in a test tube.

wide, and a quarter of an inch in thickness: it is suspended with the broad side vertical, in a brass stirrup carrying a divided circle (*a*) by which the position of detorsion of the thread is made to coincide with the meridian, and two keepers (*b*, *b*) capable of

2.



sliding on the stem (*d*) for the purpose of holding a metallic reflector (*m*). This important part of the apparatus is a small speculum weighing about one pound, four inches in diameter, and of about sixteen inches focus; it can be set to any required height on the stem (*d*) and be made to form any required angle with the axis of the magnet. The whole suspended weight amounts to about four and a quarter pounds, requiring a strong silk suspension; hence that the effect of torsion may be moderate it is desirable to have it of considerable length.* At Toronto, three wooden pillars, firmly fixed in the ground, and passing through the floor (without contact) carry a triangular frame on which is erected a light tripod stand, which passes through an upper floor, and supports the reel to which the suspension silk is attached, allowing a length of about ten feet. Stone pillars would be preferable, and have indeed been prepared for another instrument, a bifilar, on the same principle, which will, it is hoped, be brought into operation in the course of the present spring; it is probable that many interesting enquiries will arise out of oscillations so minute, that

* A long silk suspension is, however, liable to the inconvenience of varying sensibly in different hygrometric states of the atmosphere, thereby disturbing the adjustment of the light sufficiently in some cases to make it ineffective. A fine metallic suspension, as was originally used by M. Gauss, for his declinometer, if very long, would probably be preferable to silk.

nothing but extreme care, in cutting off every source of external or mechanical agitation, will give security to them. Mr. Brooke has given a curious lithograph of a trace produced under extreme "local disturbance," namely, a *quadrille party* in the house adjoining, which is sufficient to shew that if the tremor communicated from such sources does not altogether annul the magnetical movements, it materially modifies them. It will also be found necessary to adopt some means of rapidly reducing the natural movements of the magnet, of which by far the best, is the application of a heavy copper ring or damper, as shown in the preceding diagram (f); if the bar be very strongly magnetized, a fine wire dipping into mercury may be attached to it, but where the magnetism of the bar is feeble, or the horizontal component of the force has a low value, this method seems objectionable.

We have already described the lamp. It will be seen that when placed before the mirror an image of the vertical slit through which the light passes will be formed in the conjugate focus: this image being condensed to a point, by the intervention of a lens of any kind, any angular movement of the magnet and mirror will cause a movement of that point through a space equal to twice the tangent of the angle, to radius the distance of the image from the mirror; the trace can therefore be made upon any required scale, by varying that distance. At 7 ft. 2 in. it will be 20′ to 1 inch, at 9 ft. 6½ in. it will be 15′, and at 11 ft. 11¾ in. it will be 12′ to 1 inch; the distance to be selected must be determined by the probable range of the element in ordinary magnetic disturbances, for since very great ranges are of rare occurrence and seldom more than momentary, it does not seem expedient to reduce the scale sufficient to include them, at the sacrifice of distinctness in the more usual movements.* The scale at present in use at To-

* The width of the half sheet of paper is sufficient for a range of 40′ of declination and ·008 of horizontal force, upon the largest scales likely, under any circumstances, to be adopted, namely 10′ of declination and ·002 of horizontal force, to one inch. It appears from observations at Toronto, from 1840 to 1849 inclusive, embracing altogether about 3050 days, and including 164 occasions of extra observations, and 118 term days, that great ranges may be expected at that station in the following proportion.

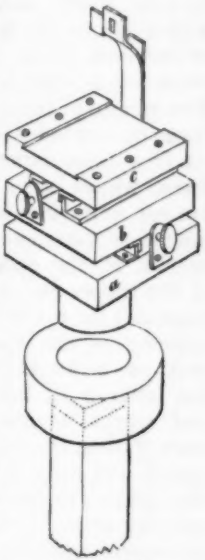
Range of Declination.		Range of Horizontal Force.	
Less than 40′	2978 days.	Less than ·008	2974 days.
From 0° 40′ to 0° 50′	28	From ·008 to ·010	17
0° 50′ to 1° 0′	12	·010 to ·015	19
1° 0′ to 1° 10′	4	·015 to ·020	7
1° 10′ to 1° 20′	7	·020 to ·025	9
1° 20′ to 1° 30′	2	·025 to ·030	3
1° 30′ to 1° 40′	2	·030 to ·035	7
1° 40′ to 1° 50′	1	·035 to ·040	3
1° 50′ to 2° 0′	4	·040 to ·045	2
2° to 3°	6	·045 to ·050	1
3° to 4°	2	·050 to ·055	2
More than 4°	3	More than ·055	11

On 211 of the term days and disturbances, the range of declination fell within the above limits, (40′) and on 207 of them, the range of horizontal force fell within the

ronto is 20′ to an inch, the light being thrown in such a way as to divide the space unequally, and allow the greatest range to the east, the direction in which the principal movements occur.

The lamp is supported by a tripod stand about three feet high, with an elevating lever for raising the top, which consists of three distinct parts: the lowest of these (*a*) turns in azimuth round a pivot, the second (*b*) slides by a slow motion screw, in a groove, on the face of the first, the third (*c*) slides in like manner on the second, but transversely: by these arrangements, first, the luminous slit can be set at any required height, secondly, it can be turned in azimuth until the brightest part of the ray falls on the centre of the mirror, thirdly, its distance from the mirror can be adjusted until a sharp focal image is formed on the cylinder, lastly, it can be moved laterally, so as to carry the image to any part of the paper required; this effect can be produced also by turning the mirror itself a little, but not with the same facility. The upper plate is provided with a groove, into which the lamp is made to fit, thus securing its being replaced after each change in precisely the same position; it also carries the screen. The slit through which the light passes is about 0·4 (four-tenths) inch high and from one to two-hundredths of an inch wide; the width can be varied at pleasure by a sliding piece and slow-motion screw.*

3.



Lamp stand.

The stand for the support of the cylinder, requires, like that of the lamp, some means of adjustment in height. If a barometer is connected with the apparatus, a ready means of attaching it so that the index may pass through the table top near the cylinder, must also be considered; both objects may be obtained by adding a solid table top about sixteen inches square to a tripod stand similar to that of the lamp, the feet of which should rest on a solid support.

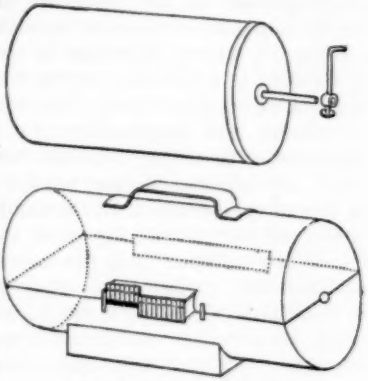
---

limit allowed for that element. It is to be expected that many more disturbances in proportion will be recorded by the photographic process than were observed, but not of the more extreme degrees, or such as to alter materially the above scale of relative frequency.

* The position of the stand for the lamp must be such that the cone of rays reflected from the mirror shall not quite clear the chimney, which cuts off a portion of one edge of it, while a portion of the other edge is cut off by a screen slipped a little before the mirror: seen therefore from the centre of the cylinder, the chimney should hide a small segment of the mirror on one side, and the screen a similar segment on the other.

The cylinder consists of an ordinary French glass shade, blackened on the inside, about fourteen and a half inches in circumference and ten inches high. One end is closed by a metal cap provided with a concentric axis, three inches long, a bent arm or crank is attached to the axis by a set screw, and engages with a slit in the hour hand of the time piece, by which the whole is made to revolve. The weight of the cylinder is borne upon five friction rollers set in a light frame; two of them, which carry the axis, are set vertically facing the time piece, two more, of smaller size at the opposite end of the frame, are sufficiently separated for the body of the cylinder to rest upon them, near its hemispherical end; the other is set horizontally, and works against a small brass plate at the base of the axis; the whole should be carefully turned and truly pivoted. In the arrangement of the inventor, after placing the paper on the cylinder as here described, a second cylinder very slightly larger is slipped over it, and retained in a concentric position, by pressure upon a few coils of tape wound round the capped end of the inner cylinder and kept wet; the object is to protect the paper and keep it damp, for which purpose, also, a piece of wet lint is placed between the cylinders at the point. An accident to the external cylinder led to the adoption of a different plan at Toronto, which has been found so convenient that the former one has not been reverted to. The external cylinder is replaced by a case of copper, of about the same size and shape, but divided along the axis into two halves, one of which is fixed to the frame carrying the friction wheels, (of which, the two carrying the axis, run altogether outside of it, the others enter it through narrow cuts, sufficiently to carry the cylinder clear); the other half forms a covering removable at pleasure. The light is admitted through two narrow slits, which may be glazed if desired. The advantages of the arrangement are these. The time piece has but half the weight to turn; the paper is immediately accessible; the loss of light in passing through the external cylinder is avoided, since it is found in practice unnecessary to glaze the opening, the impressions are therefore darker; the paper may be applied, and removed with great expedition, and without exposure to stains from contact with the

4.



Cylinder and Copper case.

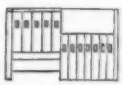
wet edges of the external glass cylinder; lastly, we are enabled, by the employment of the sliding screens described below, to make use of nearly the whole width of the paper for barometric changes, instead of being restricted to about one-half of it. It should be added that by making a shallow well in the fixed half of the cylinder, a large surface of wet lint may be exposed immediately under the paper, which is found to keep it damp enough under all circumstances, even when the slits are open.

The barometer employed, is a syphon, "constructed with a column of mercury of a little more than one inch in diameter. As the weight of an entire column of this size would be inconvenient, and as it would be difficult to obtain a tube more than three feet long of so large a bore, both ends of which were of the same internal area, two adjacent short pieces of a very nearly cylindrical tube, have been united to the extremities of a tube of small bore, and form the ends of the instrument which contain the surfaces of the mercury," thus shewing the variations of pressure by an equal change of half the amount in either tube. These changes are communicated to a long and slender index or lever by means of a float, attached to a short arm at right angles to it, both being centred on a light wheel of metal, carefully pivoted, and both being counterpoised. The float actually employed is the bulb of a mercury thermometer, the stem of which passes through a cap adapted to the open end of the syphon, and is guided by three small friction rollers.* A screen of card or very thin metal, provided with a narrow slit exactly thirty inches from the centre of motion, is attached to the upper end of the long index, covering an opening in the copper case of the cylinder; a lamp being then fixed behind the screen, the pencil of light which falls on the paper through the slit left for the purpose, will, it is evident, follow every change in the position of the index, or of the surface of mercury in the syphon. A lens similar to that which is used to bring the elongated image of the slit reflected from the mirror of the magnet to a point, is also used here to bring the image of a horizontal slit in a corresponding screen before this lamp, to a focus on the paper. It forms a bright line across its whole width, which is however intercepted by the barometer screen on one side, and by an independent screen on the other, allowing to reach the paper, only the variable pencil passing through the former and an invariable one, for the purpose of tracing a base line through a fixed opening in the latter.

The tube of the barometer has a vertical movement, to allow an adjustment of the level of the mercury at the foot of the syphon, to the same horizontal plane, so that whatever be the pres-

* These have been generally dispensed with, at Toronto, and the end of the syphon left open: unless very truly turned, and perfectly centred, they are apt to impede rather than assist the motion of the stem of the float.

sure at the time of commencing a trace, the long index is set vertically. By varying the ratio of the lengths of the two levers we may enlarge the scale of the trace to any extent; for this purpose there are distances marked on the short arm, corresponding to a scale of three, four, and five times the actual change, and the axis to which the arms are fixed can be moved nearer to, or further from the float as required. The nature of the scale must in general depend upon the probable extent of the barometric changes in twelve or twenty-four hours; it may be greater in the summer than in the winter months, but there will always be some changes exceeding the range of the instrument, or rather, the width of paper available for their registration. As, for instance, when the barometer falls or rises an inch in twenty-four hours: in such cases the index may be brought afresh to the vertical position during the progress of the register. Not to interfere with the magnetical curve, the barometer should be so placed as to form its trace rather on one side of the paper, thus reducing the space available in that direction to about one-third of its width; but by a particular contrivance connected with the copper case already described, we are enabled, without liability to exposure, to command nearly the entire width in the other direction. This contrivance consists of a set of twelve narrow parallel sliders, occupying in width about 1½ inch, moving vertically in a frame attached to the upper half of the cylinder, and capable of being raised or lowered at pleasure. At the commencement of a trace, we may suppose half of them to be raised; the remainder being down, the screen at the top of the index completely excludes all other light from the paper than the pencil passing through its own slit; but if the barometer falls beyond a certain amount, the edge of the screen will at length pass beyond the last slider, leaving a portion of the paper fully exposed; in such a case, one or more sliders are put down: if on the other hand the barometer rises to a certain amount, the light will at length fall on the space covered by the sliders, and it becomes necessary to raise some of them; in this way, the black bands caused by the accidental exposure of the paper, under extreme movements of the barometer, may be avoided.



The cylinder, with the two fixed lenses, the time piece, and the upper end of the barometer index, are all included under a second or external case, provided with apertures for the admission of the rays of light, and with a lid at the top to allow access to the sliding screens of the barometer. The apertures are of the same width as the fixed lenses, and each provided with double sliders by which they can be contracted at pleasure; that appropriated to the magnetical trace is protected by a long rectangular tube, the effect of which is so complete, that "not the slightest difference can be perceived on the paper whether bright daylight is freely admitted into the room or wholly excluded."

Every part of the apparatus from which light can be reflected, directly or indirectly, to the paper, is carefully blackened.

I have described the apparatus at some length, because with the exception of the speculum, the cylinder itself, the time piece, and the tube of the barometer, all of which must, at present, probably, be procured from Europe, there is nothing which an ingenious mechanic might not execute at a small cost; the fixed lenses should perhaps be added; but a simple substitute for them may be found in a well blown cylinder of thin glass filled with alcohol, as was indeed employed by Mr. Brooke in his first instrument. The more expensive lenses at present in use are manufactured by Lerebours of Paris, and may be described as lenticular prisms having a double convex section, but forming a flat bar, which is from seven to eight inches long and one inch and a quarter wide for the magnetical curve, and about five inches long for that of the barometer and base line. Each lens is mounted on a light frame which slides in a groove so as to admit of adjustment of focus. The focus is rather improved by covering a portion of the margin of the lens.

It is advisable on the first adjustment to bring the centre of the mirror, of the cylinder, and of the slit before the lamp, into the same horizontal plane, and to establish some marks for its recovery in successive adjustments, as much of the perfection of the focus depends upon this circumstance. If it is found that the mirror when thus adjusted, throws the image of the slit too high, or too low, its own inclination must be altered by introducing a small wedge of cork behind it. Small derangements produced by spontaneous alterations in the length of the suspension silk may be corrected by raising or lowering the lamp, and must be carefully attended to.

A perfectly good trace, according to the experience of the writer, presents a sharp edged dark line, of a purple tint, upon a yellowish ground. The lineal value of one hour in time, is one inch and two-tenths (nearly), the value of a full revolution appears to differ in different traces (from unequal expansion and contraction of the paper) to the amount in the most extreme cases of about one-tenth of an inch, upon a total length of nearly fourteen and four-tenths; but it will be evident that the precise equality of the different hours will depend in some measure upon the regularity of the cylinder's form, and the precision with which it is centered. There appears to be considerable diversity in the character of the traces produced by different observers, owing both to differences of treatment, and to impurities in the chemical materials. The yellow ground alluded to, is probably the effect of the large proportion of iodid of potassium employed, the object of which is, to insure the permanence of the effect for the long period of twenty-four hours, during which a part of it, at least, is to be maintained upon

the surface of the paper; when a less quantity of iodid is used, the paper appears to have a neutral tint: in this case, the beginning of the trace can sometimes be with difficulty developed. The greatest care must be taken not only to prevent the least intermixture of substances, and to confine each vessel, and each cloth, as well as each brush strictly to one use, but also to wash all the brushes very carefully in pure water after use, not only for their preservation, but because the presence of deposit from old solutions, even of the same kind, has an injurious effect.

A room of 12×15 feet is all that is absolutely needed for a single instrument. It will be found very desirable to have a small cistern of soft water in it, provided with a stop cock, and with a sink and waste water pipe attached; the sink should have a lid to allow the paper to be kept in darkness, when convenient, without darkening the room: if to this we add two or three broad shelves, or small tables and conveniences for washing the hands, its equipment will be complete.

The future comparison of traces will be greatly facilitated if they all include the same period of absolute time. Each register at Toronto begins at $20^{\prime}$ after 6^{h} of Göttingen mean time, and terminates at $6^{a}\ 0^{m}$ of the following day, being nearly at Toronto noon.

"A continuous registration of the variations of the thermometer has been obtained by intercepting the focal line of light formed on the paper, by the stem of a thermometer having a wide flat bore, a sufficient quantity of light passes through the empty portion of the bore to darken the paper, but it is entirely excluded from the portion occupied by the mercury. The register, therefore, consists of a light and dark space, separated by a well defined boundary line the distance of which from the base line will furnish the required indication. This particular application of the apparatus, prefers no claim to novelty, as a very similar means of registering the variations of the thermometer has been already published, (Engineer's Magazine, Nov., 1845,) and is here introduced merely as forming a necessary part of a complete automatic meteorological registration."

Allusion has been made at the commencement of this article, to the action of light upon silvered plates, as one of the modes of effecting the self-registration of magnetical instruments. The apparatus referred to is the invention of Mr. Ronalds, and although capable of employing either paper or metallic surfaces, is properly designed for the latter, and is essentially a daguerreotype. An instrument on this principle was sent from England for the Magnetic Observatory in August last, but by accident to the vessel, has not yet been received there, and cannot now be brought into operation before June, 1850. It is intended to register the horizontal force, and differs essentially in many respects from the ap-

paratus of Mr. Brooke. A bifilar magnet adjusted in the ordinary way, carries a light movable screen, passing before the object glass of a camera, which faces a north window, at the distance of four or five feet. It acts therefore by refraction, instead of reflection. The ray which passes through the screen is received upon a silvered plate prepared by the common daguerreotype process, somewhat modified to adapt it to a slow and long continued action. The plate is made to travel slowly before the light in a vertical plane, by the action of a time piece: the distance of its surface from the centre of the magnet being about thirty-four inches, a sufficiently large scale is allowed to render sensible very small movements of the horizontal force, provided a due degree of sensibility is given to the balance of forces by which the magnet itself is held in equilibrium. In other words, provided the ratio $\frac{F}{G}$, in the common notation, is made to approach nearly to unity. Mr. Ronalds has succeeded, in the climate of London, in producing effects by natural light so late as 8 P. M. in the summer. For the nocturnal portion of the curve a powerful argand lamp is employed.

The relative merits, in practice, of the two valuable and ingenious inventions now described, can scarcely be stated at present. That of Mr. Brooke has probably the advantage in economy and facility; that of Mr. Ronalds will, it is expected, prove capable of a higher degree of precision, and it offers a convenience of which the inventor has already availed himself. Any trace of unusual interest can at once be engraved on the plate, thus giving the utmost possible accuracy and facility to graphical comparisons. It is not intended however under ordinary circumstances to retain the impressions, but after recording every particular of interest, and tabulating the hourly or other ordinates, or taking a copy of the traces, to clean them off and make use of the plate again as long as the silvering lasts.

In conclusion the writer begs leave to add that should the foregoing account lead to the establishment of any instruments of the kind, he will have pleasure in giving any further information in his power in answer to personal enquiry. Without presenting facsimiles, it is difficult to convey an idea of the interest attaching to many of the movements which have been registered, but the important information which such records are calculated to afford as to the periodicity of certain movements, the nature and degree of local anomalies in disturbances of the magnetical elements, the effect of Aurora, and many other enquiries, will occur immediately to any one interested in terrestrial magnetism, and it is hoped secure the adoption of a register upon one or the other principle, by more than one of the numerous scientific establishments in the United States.

Toronto, January 21, 1850.

Postscript.—In the foregoing account of the instrument of Mr. Brooke, it has been assumed that the arm of the cylinder is connected directly with the hour hand of the time piece, making it therefore revolve once in twelve hours. The effect of this arrangement is, that when the paper is left on for twenty-four hours, we have two traces, which sometimes intersect in such a manner, as to make it difficult to distinguish to which revolution portions of them are due. The writer has recently succeeded, by a very simple arrangement, in making the cylinder revolve but once in twenty hours, and thus remedying this inconvenience. Two small grooved wheels mounted on a light frame, one having a diameter exactly double that of the other, are connected by a piece of fine silk twist. The smaller one being then connected with the hour hand, by a crank, and the larger one with the cylinder, it is evident that the object is effected.

This reduces the time scale to six-tenths of an inch for one hour, which is fully equal to the scale that has been generally adopted in the engraved diagrams of term day and other movements, and is considered large enough for almost every purpose to which diagrams can be applied, while it gives great facility to comparisons, and a much more distinct representation of the diurnal curves.

Art. XXXIII.—*Influence of the known Laws of Motion on the Expansion of Elastic Fluids;* by Eli W. Blake.

That under the controlling influence of the known laws of motion, elastic fluids must expand according to some definite and invariable law, is an obvious truth and one which has often been recognized by mathematicians. But the determination of that law is a problem which hitherto, it is believed, has not been solved. There are many interesting points in mechanics and physics, in relation to which the present state of knowledge is imperfect, which depend for their correct and complete development, in part at least, on a solution of this problem. It is therefore a point of some interest to science. It is our purpose in this article to solve this problem; and we shall do so by employing a method similar in part to that employed in solving the problem of the propagation of pulses in elastic media, ii ser., vol. v, p. 372, of this Journal.

Before entering upon the investigation we will here state one curious and remarkable fact which the investigation discloses. We advert to it here because a fact so much at variance with preconceived notions may be interesting to those readers who will not care to follow out the mathematical details of this article.

When a fluid passes by free expansion from one state of density to another, we should naturally suppose that it must pass through all the intermediate states of density that can be assigned between the two. Such appears to have been the notion of every writer who has made reference to this point; and at first view it would seem absurd to suppose that the fact could be otherwise. But such is not the way in which elastic fluids expand. On the contrary the parts of the fluid successively and *instantaneously* change their density, to the extent of one half (when free to expand to that extent) *without passing into the intermediate states.* As vapor is thrown off from the surface of water in a tenuious state *ab initio*, and without having first passed into those states of density which are intermediate between the density of the water and that of the vapor, so a column of rarefied fluid is thrown off from the front of a denser column; each infinitesimal element of the highest order of the denser column, being successively and instantaneously transformed to the more rare state. And as the change of density is instantaneous, so likewise the entire velocity due to that change is imparted instantaneously to each element successively.

But to proceed with the investigation; suppose a straight tube of uniform calibre extending indefinitely in both directions from a given point. Suppose the tube on one side of this point to be filled with a column of fluid of the density D, indefinitely expansible, and always maintaining the same ratio between its density and elastic force when it expands; and suppose the other portion of the tube a perfect vacuum. It is required to determine the law according to which the fluid expands into the vacuum; so that we may be able to assign the precise state of the fluid, in respect to density and velocity, at each and every point of the tube after the lapse of any given time from the commencement of expansion.

Since the elastic force is always as the density, D may represent both the density and the elastic force. The force D acts during the first instant in every part of the column, and in *every direction;* and therefore during that instant every part of the column is kept in equilibrio except the first element. Consequently in the first instant expansion takes place in the first element only; and as the whole force D acts during that instant, the parts of this element must receive such velocities that the sum of their momenta shall be equal to that due to the action of the constant force D during that time. It is obvious that the termination of the first instant coincides with the commencement of motion in the second element; also that motion will not commence in the second element until the density in front of it has been to some extent reduced. Let the ratio in which it is reduced before motion begins in the second element be represented

by $\frac{1}{x}$. Then the density of the posterior part of the expanded element at the end of the first instant is $\frac{D}{x}$. Now for reasons which will soon be apparent, all the other parts of the expanded element, whatever may be their present state of density, may be considered as having passed first into the density $\frac{D}{x}$. But at the same time that the grade $\frac{D}{x}$ began to form in front of the column, that grade itself must have begun to expand *again* in the same ratio, forming another grade $\frac{D}{x^2}$. And at the same time that the grade $\frac{D}{x^2}$ began to form, that likewise must have begun to expand in the same ratio forming a grade $\frac{D}{x^3}$, and so on ad infinitum. The grades therefore will correspond to the terms of an infinite series in decreasing geometrical progression. All of them originate *simultaneously* in the first element; and yet every grade respectively may be considered as having passed into and out of all the grades which precede it; inasmuch as each in its origin is a *constituent part* of that which precedes it. The fluid which passes into any one of these grades in the first instant does not all of it pass into the next in the same time; for equal quantities by *measure* expand in equal ratios in equal times; and since a given quantity by measure in any one grade becomes a larger quantity by measure when expanded into the next grade, a portion will have been left at the end of the first instant in each grade which has not expanded into the next. Hence at the end of the first instant the first element of the column will have been distributed into portions or grades, having their respective densities corresponding to the terms of the infinite series

$$\frac{D}{x}, \frac{D}{x^2}, \frac{D}{x^3}, \frac{D}{x^4}, \text{ \&c.} \qquad (A)$$

If we extend this series backward one term we obtain the series

$$D, \frac{D}{x}, \frac{D}{x^2}, \frac{D}{x^3}, \frac{D}{x^4}, \text{ \&c.} \qquad (B)$$

Since equal quantities by measure pass out of each of these states in a given time, if s be the space occupied by the original element, and if we multiply each of the terms of the series (B) by s, then the terms of the resulting series

$$Ds, \frac{Ds}{x}, \frac{Ds}{x^2}, \frac{Ds}{x^3}, \frac{Ds}{x^4}, \text{ \&c.} \qquad (C)$$

will severally express the quantities of fluid that expand from

each grade respectively into the next. Now since fluids expanding in equal ratios acquire equal velocities, equal velocities are acquired in each of these expansions. If then we find that velocity and by it multiply the sum of the series (C), the product will be the sum of the momenta generated in, or imparted to, the parts of the first element in the time in which the point of expansion recedes through s.

If the quantity Ds be expanded from the density D to the density $\frac{D}{x}$, the space it will occupy will be increased in the inverse ratio of these densities; and therefore $\frac{D}{x} : D :: s : sx$. Hence s and sx are respectively the spaces occupied by the element before and after the first expansion. Now the velocity which the mass Ds receives in this expansion, is obviously that which would carry it over the difference between these spaces in the time in which the expansion takes place; that is, the velocity imparted in the first expansion is $sx - s = s.\overline{x-1}$; and the same velocity is imparted in every other expansion. If then we multiply the sum of the series (C) by $s.\overline{x-1}$, the product will be equal to the sum of all the momenta generated in the parts of the element. This product is $Ds\,x$. Therefore Ds^2x is the entire amount of momentum which the force D is competent to generate in the time in which the point of expansion recedes through s.

We will now proceed to find another expression for the momentum which the force D is competent to generate in the same time, in order that by comparing it with that just found, we may ascertain the value of x.

Let H be the height of a column of fluid of the density D, whose weight is equal to the elastic force D; and let $H - h$ be the height of another column of the same density whose weight is equal to the elastic force $\frac{D}{x}$. Then $D : \frac{D}{x} :: H : H - h$. Let mn be the space occupied by the first element at the density D, and ms that which it occupies when expanded to the density $\frac{D}{x}$. Since the spaces occupied by the element in these states are inversely as the densities, $mn : ms :: \frac{D}{x} : D :: H - h : H$, and therefore

$ms - sn : ms :: H - h : H$; whence we obtain $H = \frac{h \times ms}{sn}$.

In the time in which the point of expansion recedes through mn, the element Ds receives a velocity which will carry it over sn in the same time. If then mn represent the velocity of the

point of expansion, *sn* will represent the velocity imparted to the fluid by the first expansion. Consequently, the retrogressive velocity of the point of expansion must be such that in the time in which it passes over any space, the force $D-\frac{D}{x}$ may give to all the fluid in that space the velocity *sn*. Hence the point of expansion will run over *h* in the time in which the force $D-\frac{D}{x}$ will give to all the fluid in *h* the velocity *sn*. But the force $D-\frac{D}{x}$ is equal to the *weight* of all the fluid in *h*. Therefore the point of expansion runs over *h* in the time in which the mass *h* would in falling by its own gravity acquire the velocity *sn*. The time in which a falling body acquires the velocity *sn* is to that in which it would acquire the velocity of the point of expansion, or *mn* as *sn* to *mn*; and the spaces over which the point of expansion would run in these times are in the same ratio. Therefore putting S for the space which the point of expansion would run over while a falling body would acquire the velocity of the point of expansion, we have $sn : mn :: h : S$, or, $sn : ms - sn :: h : S$; whence we obtain $S=\frac{h \times ms}{sn}-h$. But we have before found $H=\frac{h \times ms}{sn}$. Therefore $S=H-h$; that is, the point of expansion will run over $H-h$ in the time in which a falling body will acquire the same velocity. Consequently the velocity of the point of expansion is that which a body will acquire by falling through $\frac{H-h}{2}$.

If the force D act on the mass H during the time that mass would fall through H, it would give that mass a velocity which would carry it over 2H in the same time, because the force D is equal to the weight of the mass. The mean velocity of a body falling through H is that which will be acquired by falling through $\frac{H}{4}$. If then the point of expansion moved with the velocity acquired by a body in falling through $\frac{H}{4}$, in the time of passing over H, the force D would be competent to give to all the fluid in H a velocity which would carry it over 2H in the same time; and consequently in the time of passing over *s* it would give to the mass D*s* a velocity which would in the same time carry it over 2*s*. But the point of expansion as before shown, moves with the velocity acquired by falling through

$\frac{H-h}{2}$. Now the velocity due to $\frac{H}{4}$ is to that due to $\frac{H-h}{2}$ as $\sqrt{\frac{H}{4}}$ to $\sqrt{\frac{H-h}{2}}$; and the times in which the point of expansion would move over s with these velocities, are inversely as these velocities, or as $\sqrt{\frac{1}{\frac{H}{4}}}$ to $\sqrt{\frac{1}{\frac{H-h}{2}}}$. But $D:\frac{D}{x}::H:H-h$, and therefore these times are as $\sqrt{\frac{1}{\frac{D}{4}}}$ to $\sqrt{\frac{1}{\frac{D}{2x}}}$, or as 2 to $\sqrt{2x}$. The velocity which the force D can impart in these times is as the times respectively. And since it has been shown that in the former of these times the velocity $2s$ will be imparted by the force D, we have $2 : \sqrt{2x} :: 2s : \frac{2s\sqrt{2x}}{2} = s\sqrt{2x}$. That is, the *velocity* which the force D is competent to impart to the mass Ds in the time in which the point of expansion recedes through s, is $s\sqrt{2x}$. Consequently the *momentum* which the force D can impart in the same time is $Ds^2\sqrt{2x}$. But we have before found this momentum to be Ds^2x. Therefore $Ds^2x = Ds^2\sqrt{2x}$; whence $x = \sqrt{2x}$ and $x = 2$.

Having thus found the absolute value of x, if we substitute this value for x in the series (A) we shall have, for the densities of the several parts or grades into which the first element will have been distributed at the end of the first instant, the respective terms of the following series, viz., $\frac{D}{2}, \frac{D}{4}, \frac{D}{8}, \frac{D}{16}, \frac{D}{64}$, &c.

We found the velocity of the point of expansion to be that which a body will acquire by falling through $\frac{H-h}{2}$; the value of h being dependent on the value of x. But when $x = 2$, $\frac{H-h}{2} = \frac{H}{4}$. Therefore the absolute velocity of the point of expansion is that which a body will acquire by falling through $\frac{H}{4}$, or one fourth of the subtangent of the fluid.

Since the extent of the element is doubled by the first expansion, the velocity of the first grade will be equal to the velocity of the point of expansion, or that due to one fourth of the subtangent; and an equal additional velocity is imparted in each succeeding expansion. If then v represent the velocity due to

one fourth the subtangent of the fluid, the absolute velocities of the several grades respectively will be expressed by the respective terms of the series v, $2v$, $3v$, $4v$, $5v$, &c.

Since one element $=s$ by measure passes from each grade into the next, and becomes $=2s$ in the next, the length of each grade at the end of the first instant $=2s-s=s$. That is, the length of each grade is equal to that of the original element; and the *place* of the first grade is that which was occupied by the original element; the other grades succeeding it in continuous order.

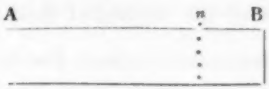
Having now ascertained the state of things at the end of the first instant, let us inquire what takes place in the second instant.

It is obvious that during the second instant the front of the second element of the column, and also the front of each grade respectively is a point of expansion from which one element $=s$ by measure passes into the next grade. Thus in the second instant each grade receives an addition of $2s$ to its rear and loses $1s$ from its front. The same takes place in every succeeding instant. Since the increment of the length of the grades for each instant is s, the velocity of the increase is v. The length of the grades is therefore always equal to the space through which the point of expansion has receded in the column. Thus while the length of the grades increases with the uniform velocity v, their number, velocity and density remain unchanged. Consequently no other gradations of density can exist in front of a column expanding into a vacuum, but those which correspond to the terms of the infinite geometrical series $\frac{D}{2}, \frac{D}{4}, \frac{D}{8}, \frac{D}{16}$, &c.; and no other gradations of velocity but those which correspond to the terms of the infinite arithmetical series v, $2v$, $3v$, $4v$, &c.

The point of expansion in the column recedes with the velocity v; and since the length of the first grade is always equal to the space through which that point of expansion has moved, it follows that the point of expansion from the first into the second grade is stationary. And since the second grade increases in length with the velocity v, the third point of expansion moves forward with the velocity v; and since all the other grades increase in length with the same velocity v, the velocities of the several points of expansion will be expressed by the following series $-v$, 0, v, $2v$, $3v$, $4v$, &c.

In order to give a synopsis of the results to which we have come, let AB be a column of fluid of the density D, expanding into a vacuum toward C. Let the velocity due to a height equal to one fourth of the subtangent of the fluid be v. Suppose expansion to have commenced at B, and the point of expansion to have receded to any distance n. Set off from B an infinite number of spaces Ba, ab, bc, cd, &c., each equal to Bn. Then the points n, B, a, b, c, d, &c., are the places of the points of expan-

sion, and the boundaries of the several grades, or parts having different degrees of density and velocity, into which the original mass B*n* has been distributed.



Between these points respectively the densities are	.	$\frac{D}{2}$.	$\frac{D}{4}$.	$\frac{D}{8}$.	$\frac{D}{16}$.	$\frac{D}{64}$.	&c.
The velocities are	.	v .	$2v$.	$3v$.	$4v$.	$5v$.	&c.
These points move toward C with the velocities	$-v$	0	v	$2v$	$3v$	$4v$	&c.
and relatively to each other, and to the fluid, with the velocities	v	v	v	v	v	v	

As corollaries from the preceding investigation we may state the following propositions.

1. No other gradations of density can exist in front of a column of fluid which is expanding towards a vacuum except those which are found by successive divisions of the original density by 2.

2. The change of density in the fluid in passing from one of these grades to the next is not *gradual*, but *instantaneous;* so that the grades are constantly separated from each other by a mere imaginary plane.

3. No other velocities can exist among the parts of a fluid which is expanding toward a vacuum but such as are multiples of the velocity which a body will acquire by falling through one fourth of the subtangent of the fluid.

4. The velocity imparted to the particles of an expanding fluid is not the result of a continual and gradual acceleration, but of successive instantaneous increments equal to that which a body will acquire by falling through one fourth of the subtangent of the fluid.

It now remains to consider the mode of expansion when the fluid is not free to expand indefinitely, but has its expansion arrested at some given density *d*.

It is obvious that if *d* correspond in value to any of the terms of the series, the manner of expansion up to that point will be the same as if the expansion were continued indefinitely. There will therefore be in the expanding fluid, in such case, so many grades corresponding to the terms of the series, as there are of complete terms intervening between D and *d*. But let us inquire what takes place when *d* does not correspond to any of the terms of the series. First, suppose *d* to be greater than the first term. Then from what has been before shown, the velocity of the point

of expansion is that which a body will acquire by falling through $\frac{H-h}{2}$ when $H-h$ is the height of a column whose weight is equal to the elastic force of the expanded fluid; also that the velocity of the point of expansion is that due to the height $\frac{H}{4}$ when the expansion is from D to $\frac{D}{2}$. These velocities are as $\sqrt{\frac{H}{4}}$ to $\sqrt{\frac{H-h}{2}}$ and since $H : H-h :: D : d$, those velocities are as $\sqrt{\frac{D}{4}}$ to $\sqrt{\frac{d}{2}}$. The velocity due to $\frac{D}{4}$ is v. Hence we have $\sqrt{\frac{D}{4}} : \sqrt{\frac{d}{2}} :: v : v\sqrt{\frac{2d}{D}}$ = velocity of the point of expansion in this case.

Let us next find the velocity of the fluid. The times of running over s by the point of expansion, with the velocities $\sqrt{\frac{D}{4}}$ and $\sqrt{\frac{d}{2}}$ are inversely as these velocities; and the velocities imparted to the mass Ds in these times are as the products of the times by the respective forces. When the velocity of the point of expansion was $\sqrt{\frac{D}{4}}$ the force was $\frac{D}{2}$ and the velocity of the fluid was v. The force in the present case is $D-d$. Hence we have

$$\frac{\frac{D}{2}}{\sqrt{\frac{D}{4}}} : \frac{D-d}{\sqrt{\frac{d}{2}}} :: v : v\sqrt{2} \cdot \frac{D-d}{\sqrt{Dd}} = \text{velocity of the fluid in this case.}$$

Secondly, suppose the value of d to fall between any two consecutive terms of the series. It is obvious that we have now only to substitute in the expression last found that term of the series which is next greater than d for D, and it will then express the acceleration due to expansion from the last complete term into the fractional grade.

To find the retrogressive velocity of the point of expansion, relatively to the fluid, in the grade which precedes the fractional grade, we must make the like substitution of the last complete term for D in the quantity $v\sqrt{\frac{2d}{D}}$ found above. The retrogressive velocity of the point of expansion in the grade which precedes the fractional grade is greater than in the other grades, and of course that grade will be shorter than the others in the

same ratio. This is the only modification which a fractional grade produces in those that precede it. In all other respects the mode of expansion, up to the fractional grade, corresponds to the view presented in the foregoing synopsis.

We are now prepared to construct a formula for the final velocity of a fluid which expands from any density D to any other density *d*.

Let V be the final velocity; *v* the velocity due to a height equal to one fourth the subtangent of the fluid; *n* the number of complete terms of the series $\frac{D}{2}, \frac{D}{4}, \frac{D}{8}, \frac{D}{16}$, &c., which intervene between D and *d*.

Then *vn* is obviously the velocity of the grade which precedes the fractional grade, if there be a fractional grade. When the first grade is fractional we found its velocity to be $v\sqrt{2}\cdot\frac{D-d}{\sqrt{Dd}}$; and we also found that to suit this expression to the case of a fractional grade occurring elsewhere in the range of the series, we are to substitute for D that term of the series which is next greater than *d*. Now the value of that term will be $\frac{D}{2^n}$. Making the substitution accordingly, the expression for the additional velocity due to expansion into the fractional grade becomes, after reducing, $v\sqrt{2}\cdot\frac{D-2^nd}{\sqrt{2^nDd}}$. By adding this quantity to *vn* we obtain the final velocity of the fluid, resulting from its expansion from any density D to any other density *d*. Hence the formula is

$$V=v.n+\sqrt{2}\cdot\frac{D-2^nd}{\sqrt{2^nDd}}.$$

When there is no complete term of the series between D and *d*, $n=0$ and the above formula becomes $V=v\sqrt{2}\cdot\frac{D-d}{\sqrt{Dd}}$.

When there is no fractional grade, that is, when *d* is equal to some term of the series, that part of the formula beyond *n* equals 0, and then the above formula becomes $V=vn$.

From the general principles here developed it is obvious that, as in expansion, so likewise in *condensation*, the transition of an elastic fluid from one density to another is not by gradations which may be represented by a curve, but abrupt, instantaneous, *per saltum vel saltus*. Pulses, therefore, which are propagated in elastic fluids partake of the same character; that is, the condensation and subsequent reëxpansion of the successive elements through which the wave moves is instantaneous. This fact was not known when the article on the propagation of pulses, referred to at the commencement of this article, was written. It however does not affect the validity of the reasoning in that article.

XXXIV.—*On the Rotation of the Plane of Polarization of Heat by Magnetism;* by MM. F. de la Provostaye and P. Desains.*

Shortly after the brilliant discovery of Prof. Faraday of the rotation of the plane of polarization of light by magnetism, M. Wartmann announced† that he had tried the same experiment with radiant heat. He employed the heat of a lamp, which he partially polarized by making it pass through two piles of mica crossed at right angles. The electro-magnets and a cylinder of rock-salt were placed between these piles, and consequently very near the thermo-electric apparatus. The galvanometer, on the contrary, to be preserved from the action of the electro-magnets, was removed to a great distance; but the result was a considerable increase in the length of the circuit, and a diminution of sensitiveness.

Notwithstanding all these inconveniences, which he clearly pointed out, and which he was not able to overcome, M. Wartmann thought he observed that the needle of the galvanometer, after having attained a fixed deviation under the influence of the radiation not intercepted by the piles of mica, was again displaced and took a fixed position different from the first when the current was established, which seemed to indicate a rotation of the plane of polarization of heat.

At Paris, some persons having vainly attempted to reproduce these phenomena, we have considered that it would be useful to revert to these experiments, and to point out a method which permits of making them succeed with facility.

We have introduced into M. Wartmann's process three principal modifications:—1st, we employ solar heat; 2ndly, we take for polarizing apparatus two prisms of achromatic spar; 3rdly, and this appears to us indispensable, instead of placing the principal sections at 90°, we arrange them so that they make an angle of nearly 45°.

The employment of spars and solar light permits of removing the electro-magnets to a great distance from the thermo-electric pile. With respect to the arrangement of the prisms, the law of Malus shows all the advantages which it presents. In fact, let us take for unity the deviation which the solar ray transmitted through the principal parallel sections would produce. The deviation, when the prisms form an angle of 45°, will be $\cos^2 45° = \frac{1}{2}$. If the current is set in action, and it produces a rotation of

* From the Annales de Chimie et de Physique, October, 1849,—cited from Phil. Mag., xxxv, 481.

† Institut, May 6th, 1846, No. 644.

the plane of polarization equal to δ, the deviation will be, according to the direction of the current, $\cos^2(45^\circ-\delta)$ or $\cos^2(45^\circ+\delta)$, and we shall then have, for the difference of the effects observed when the current is made to pass in a contrary direction,

$$\cos^2(45^\circ-\delta)-\cos^2(45^\circ+\delta)=\sin 2\delta.$$

On placing the principal sections at 90°, the difference of the deviations would be only

$$\cos^2(90^\circ-\delta)-\cos^2 90^\circ=\sin^2\delta,$$

or

$$\cos^2(90^\circ+\delta)-\cos^2 90^\circ=\sin^2\delta.$$

Now $\sin^2\delta$ is considerably less than $\sin 2\delta$. If, for example, we suppose $\delta=8^\circ$, $\sin^2\delta$ is equal to more than fourteen times $\sin 2\delta$.

The eye, it is true, appreciates readily the transition from darkness to light, but not so the difference in brightness of two luminous images. This is not the case with the thermoscopic apparatus. There is therefore, when heat is concerned, a great advantage in proceeding as above directed.

The following are the details of the experiment: the solar ray, reflected by a heliostat, traverses at first a doubly-refracting achromatic prism. The extraordinary bundle was intercepted: the ordinary bundle traverses the electro-magnet of M. Ruhmkorff's apparatus, and a flint-glass of 38 millimetres in thickness between the poles of the electro-magnet. It afterwards encounters, at about $3^m\cdot 50$, the second prism of spar, bifurcates again, and gives two images, one of which may be received on the thermo-electric pile placed at four metres from the electro-magnet. The galvanometer was still a little further removed from this disturbing force. It was ascertained, by direct and repeated experiments, that on establishing the current there were no phenomena of induction, and that the electro-magnets had no appreciable action on the magnetic needle which, under their influence, remained at zero in a state of perfect rest. In order to understand this, it must be borne in mind that the two opposite poles are very close together, and that they act simultaneously upon a system already very distant and almost completely astatic. It might be feared that the electro-magnet, without action on the needle at zero, acted on the needle already displaced by the action of the calorific radiation. This would be possible in fact, if, in its first position, the needle had the same direction as the line which joins its centre to the electro-magnet, and if, when it deviates, it made a notable angle in that direction. In our experiments, precisely the inverse condition was realized; so that the component of the magnetic action diminished more and more during the movement of the needle, and became perfectly null when it attained its greatest deviation. If therefore it had no action in the first case, such ought for a stronger reason to be the case in the second.

By means of a commutator the electric current could be made to pass, now in one direction, now in another, through the wires of the electric magnet. We shall designate the two currents by the abridged expressions *Current* A, *Current* B.

The following are the deviations observed :—

Experiments of September 22.

(A Muncke's battery of 50 elements with large surfaces, but already worn, was employed.)

FIRST SERIES.

	Deviations.
Current A,	21·0
Without current,	19·0
Current A,	21·4
Without current,	18·6

SECOND SERIES.

(Acid was added.)

Without current,	20·5
Without current,	20·6
Current B,	18·6
Without current,	20 9
Current A,	23 6
Current B,	18·8
Current A,	22·0
Current B,	18·0
Without current,	19·9

THIRD SERIES.

Current B,	17·4
Current B,	17·1
Current A,	19·5
Without current,	18·3

Experiments of September 29.

(A Bunsen's battery of 30 elements, well-cleaned and amalgamated, was employed.)

FIRST SERIES.

	Deviations.
Without current,	12·0
Current A,	14·9
Current B,	8 6
Without current,	11·7
Current B,	8·8
Without current,	11·8

SECOND SERIES.

	Deviations.
Without current, ...	18·4
Current B, ...	14·9
Current A, ...	21·7

It is to be remarked, that here, if the principal sections of the prisms were perpendicular, the deviation, at first null, would scarcely attain one semi-division when one of the currents was made to act.

Lastly, to obviate every objection, a third series of experiments was made by taking away the prism of flint-glass, and observing the deviations produced by the solar ray, when, as before, the electric current was made to pass in the wires of the electro-magnet, now in one direction, now in another.

Deviations.	
Current A . . . 16·5	As should be the case, the deviations are equal, which proves that the electric current and the magnet change the deviations in acting on the flint-glass and not in acting on the needle of the galvanometer.
Current B . . . 16·8	
Current A . . . 16·8	

The above experiments establish, we believe, in an irrefragable manner, the rotation of the plane of polarization of heat under the influence of magnetism.

Art. XXXV.—*Historical account of the Eruptions on Hawaii;* by James D. Dana.*

The island of Hawaii has a nearly triangular outline with the three sides fronting severally, west, southeast, and northeast. The western side is about 85 geographical miles in length, the southeast 65, and the northeast 75 miles. The whole surface pertains to the slopes of three lofty volcanic summits, Mount (or Mauna) Loa† constituting its southern portion, 13,760 feet in height, Mount Kea, long extinct, covering the northern portion, 13,950 feet in height, and Hualalai towards the western shores, estimated at 10,000.

The voyager approaching Hawaii, while admiring the sublimity of its swelling heights, is struck with the unbroken surface of the island. Lofty peaks and alternating valleys and ridges are so generally characteristic of mountain scenery, that he views the even and gentle slope of the summits Loa and Kea with a degree

---

* Extracted and condensed from the Author's Exp. Expd. Geological Report.

† This name is often written *Roa*. L and r are interchangeable letters in the Hawaiian dialect. The l sound is most common, and is adopted in the written language of the islands.

of amazement. The former rises with a scarcely perceptible inclination, (see annexed cut,) without a break in the surface apparent in the distant view; then gradually rounds over, and declines on the opposite side with the same gentle declivity. The eye following along, up and down the sides of Mount Kea, meets with the same slopes, and only few traces of indentations. Mount Loa is a flat dome. Mount Kea rises to the same altitude, and differs only in having the summit somewhat pointed.

OUTLINE VIEW OF HAWAII, FROM THE EASTWARD.

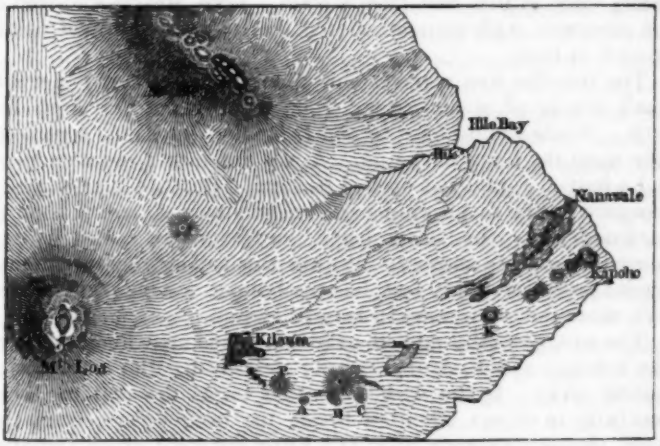
From these descriptions the statement will be appreciated that the heights of Hawaii are not peaks in a mountain range, but three isolated domes or low cones, united by a confluence of lavas at base. The surface of the island is not a mass of broken mountains, but the simple slopes of these elevations. Yet on an actual scramble over the sides, there are found extensive ravines and ridges of lava which impede the progress; and numerous craters form large elevations usually ranging between three and nine hundred feet in height. There are also numerous gorges on the eastern and northern foot of Kea, which extend from the sea half-way up the mountain, and are from three hundred to a thousand feet in depth. The Kohala range on the north, which is the only part not conformable to this system, faces the interior of the island with a nearly vertical front, while northward the slopes are less abrupt and are profoundly intersected by valleys.

Mount Kea has an average slope of 7° 46′. The slope of Mount Loa on the south averages 7° 33′; on the west 5° 28′; on the east, to Kilauea, (a distance of 19·8 miles from the axis,) 6° 42′; making 6° 30′ the average for the dome. From Kilauea to the sea, the slope averages but 1° 28′, equivalent to 135 feet to the mile. The following map of a part of Hawaii* will assist in conveying an idea of the form of Mount Loa, the position of the crater at summit, and of Kilauea on its east-southeastern flank, 3970 feet above the sea.

We may hence assume 6° 30′ as the average inclination of the great dome. This gives for the base of the dome a breadth of forty-five and three-fourths miles. This however is only the central portion of the mountain: for the slopes spread very much below,

* This map is reduced from the chart published with the Narrative of the Expedition.

diminishing eastward to a single degree, so that the region of volcanic action subordinate to Mount Loa. is about seventy miles in width, or includes the entire breadth of the island, from east to west. The main part of the mountain, if considered a portion of a great sphere,* will correspond to a segment 13,760 feet deep,



cut from a globe four hundred miles in diameter; or in form, to a segment about one-twelfth of an inch deep from a globe twelve inches in diameter: and in such a segment as last referred to, the terminal crater would be represented by an indentation one-fifteenth of an inch broad, and Kilauea by another one-tenth of an inch broad; and both about a fifteenth of their breadth in depth. The dome, consequently, instead of having slender walls at top, has a horizontal thickness of full twenty miles, eighteen hundred feet vertically below its summit.†

---

* It varies a little from a segment of a sphere, the upper parts being slightly more prominent.

† For comparison with other lofty volcanic mountains we here mention a few other inclinations, as determined in different instances.

The peak of Teneriffe has an average inclination of 12° 30′, the proportion of height to diameter being given as 1 to 9.

Etna, according to Elie de Beaumont, has an average inclination of 8 degrees. M. von Buch makes the ratio of height to circumference as 1 to 34, giving the angle 10¼ degrees. The Chimborazo dome, according to Humboldt, is only 673 toises through at a level of 153 toises (or 978 feet) below the centre of top.

It is much to be regretted that artists, when sketching mountains, are not content with giving them their actual slopes instead of attempting improvements by straightening up their sides, and sharpening their summits. Even in works of science, the same errors are common. We never see a drawing of Jorullo, which does not give the peak actually impossible slopes, taking Humboldt's own facts as a criterion. Drawings of Vesuvius and Etna, in the most prominent of our geological treatises, are equally objectionable. A simple outline, if correct, gives reliable information; and is far more valuable to science, than one improved to suit the fancy, though sketched with the skill of a master.

The two craters of Mount Loa are still active. The summit crater, called Mokua-weo-weo, measuring 13,000 and 8000 feet in its diameters, has a depth of 784 feet along its western precipice. Kilauea, the crater of most renown, is marked by no conical elevation; and the declivities of the parent mountain hardly vary in this part from a plain. Like Mokua-weo-weo it is a pit-crater, with vertical sides of horizontally stratified basaltic rock or lava.

The traveller first perceives his approach to the crater in a few small clouds of steam rising from fissures not far from his path. While gazing for a second indication he stands unexpectedly upon the brink of the pit. A vast amphitheatre seven miles and a half in circuit has opened to view. Beneath a gray rocky precipice of 650 feet, forming the bold contour, a narrow plain of hardened lava, (the "black ledge,") extends like a vast gallery around the whole interior. Within this gallery, below another similar precipice of 340 feet, lies the bottom, a wide plain of bare rock more than two miles in length.

The eye naturally ranged over the whole area for something like volcanic action, as it is usually described. But all was singularly quiet. In the dark plain that forms the bottom, there was little to attract attention beside the utter dreariness of the place, excepting certain spots of a blood-red color which appeared to be in constant yet gentle agitation. Instead of a sea of molten lava "rolling to and fro its fiery surge and flaming billows," we were surprised at the stillness of the scene. The incessant motion in the blood-red pools was like that of a cauldron in constant ebullition. The lava in each boiled with such activity as to cause a rapid play of jets over its surface. One pool, the largest of the three then in action, was afterwards ascertained by survey to measure one thousand five hundred feet in one diameter, and a thousand in the other: and this whole area, into which the Capitol grounds at Washington might be sunk entire, was boiling, as seemed from above, with nearly the mobility of water. Still all went on quietly. Not a whisper was heard from the fires below. White vapors rose in fleecy wreaths from the pools and numerous fissures, and above the large lake they collected into a broad canopy of clouds, not unlike the snowy heaps or cumuli that lie near the horizon in a clear day, though changing more rapidly their fanciful shapes. On descending afterwards to the black ledge, at the verge of the lower pit, a half-smothered gurgling sound was all that could be heard from the pools of lava. Occasionally there was a report like musketry which died away, and left the same murmuring sound, the stifled mutterings of a boiling fluid.

Such was the general appearance of Pélé's pit in a day view, at the time it was visited by the author.*

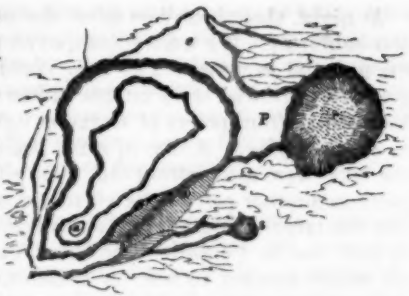
* In November, 1840.

At night, though no less quiet, the scene was one of indescribable sublimity. We were encamped on the edge of the crater, with the fires full in view. The large cauldron, in place of its bloody glare, now glowed with intense brilliancy, and the surface sparkled with shifting points of dazzling light, occasioned by the jets in constant play. A row of small basins on the southeast side of the lake were also jetting out their glowing lavas. Two other pools in another part of the pit tossed up their molten rock much like the larger cauldron, and occasionally burst out with jets forty or fifty feet in height. The broad canopy of clouds above the pit which seemed to rest on a column of wreaths and curling heaps of lighted vapor, and the amphitheatre of rocks around the lower depths, were brightly illumined from the boiling lavas; while a lurid red tinged the distant parts of the inclosing walls and threw into deeper shades of darkness the many cavernous recesses. And over this scene of restless fires and fiery vapors the heavens by contrast seemed unnaturally black, with only here and there a star like a dim point of light.

The next night streams of lava boiled over from the lake, and formed several glowing lines diverging over the bottom of the crater. Towards morning, there was a dense mist, and the whole atmosphere seemed on fire. The lakes were barely distinguished through the haze, by the spangles on the surface that were brightening and disappearing with incessant change.

We have endeavored to describe these views, with literal correctness. We are not responsible for any disappointment the account may create, as we could see only what was actually before us. Pele was in one of her sober moods. Yet we have reason to believe that this is her usual state, and assuredly there is a terrible grandeur even in her quiet. The action when most roused has been much exaggerated in its character; for boiling and overflowing, with occasional detonating explosions, constitute in every condition the characteristic features: in its greatest violence, the cauldrons are more numerous and extensive, the spouting cones multiply in number, the explosions are loud and frequent, and the sheets of lava at each overflow spread through the whole crater. Such a scene over an area seven and a half miles in circuit, must be terrific beyond description, although the "sea" be no sea; and the "waves" but the agitations of violent ebullition and frequent overflowings.

The accompanying bird's-eye view of Kilauea, reduced from the surveys of the Expedition, shows its oblong-ovate form and general features, though giving no adequate idea of its magnitude. The longest diameter lies nearly northeast and southwest, and is sixteen thousand feet in length; the average breadth is seven thousand five hundred feet. The pit includes, therefore, an area



of nearly four square miles,* thus exceeding in extent many a city of one hundred thousand inhabitants. Yet on looking into it from above, it is difficult to realize its size, as there is no object within or about it which can serve for comparison. No one would imagine that two hundred such structures as St. Peter's at Rome could be accommodated within its walls, or that the lofty dome of this cathedral would stand with its pinnacle but little above the black ledge. The great lake of boiling lava (*a*), 1000 feet by 1500, as above mentioned, is a small object in such an area.

A better idea of the internal form of the pit will be obtained from a transverse section here represented. It is taken in the line of the shorter diameter; a section through the longer diameter on the same scale (a third of an inch to a thousand feet) would not have room on the page; *m m'* is the whole breadth of the crater; *o n, o' n'*, the black ledge; *p p'* the bottom of the lower pit; *n p, n' p'* the walls of the lower pit, 342 feet in height; *m o, m' o'*, the walls above the black ledge, 650 feet in height.

VERTICAL SECTION OF KILAUEA.

The walls of the crater (*m o*) are vertical, or nearly so, through the most of their circuit. There is a break with several fissures in the northeast corner, (in the figure above, the *upper* side is *north*,) where is the usual place of descent; and on the southeast side (*o*) there are two or three sloping declivities, on which one of the famous sulphur banks is situated.

Without continuing with these details relating to the crater of Kilauea, we proceed to an account of the eruptions of which we have knowledge.

The first eruption of this crater of which tradition gives any definite knowledge, occurred about the year 1789, during the wars and conquests of Ka-meha-meha. It took place between Kilauea and the sea in a southeasterly direction. It is said to have been accompanied by violent earthquakes and rendings of the earth: and an eruption of cinders and stones from the opened fis-

* As nearly as can be ascertained from the map of the crater the area is three and two-thirds square miles, or 100,000,000 square feet.

sures. It was so violent and extensive that the heavens were completely darkened; and one hundred lives are supposed to have been lost. There are now, over a large area near Kilauea a few miles distant to the south and southeast, great quantities of a light pumice-like scoria, with stones and sand, which are believed to have been thrown out at this time.*

The famous outbreak of lavas, in 1823, and the features of the crater after it, are described by Mr. Ellis in his Polynesian Researches.† A large tract of country in Kau, the southern district of Hawaii, was flooded, and the stream, where it reached the sea, as I am informed by Rev. Mr. Coan, was five to eight miles wide. The earth is said to have been rent in several places, and the lavas were ejected through the fissures, commencing their course above ground some miles south of Kilauea. There was no visible communication with the lavas of this crater at the time; but the fact of their subsiding some hundred feet simultaneously with the eruption is satisfactory evidence of a connection. The crater after the eruption, as described by Mr. Ellis,‡ had the same general

* The following account of this eruption is from a "History of the Sandwich Islands," by Rev. I. Dibble, published at Lahainaluna (island of Maui) in 1843. It was taken by the author from the lips of those who were part of the company, and present in the scene. The army of Keoua, a Hawaiian chief, being pursued by Kamehameha, were at the time near Kilauea. For two preceding nights, there had been eruptions, with ejections of stones and cinders. "The army of Keoua set out on their way in three different companies. The company in advance had not proceeded far before the ground began to shake and rock beneath their feet, and it became quite impossible to stand. Soon a dense cloud of darkness was seen to rise out of the crater, and, almost at the same instant, the thunder began to roar in the heavens, and the lightning to flash. It continued to ascend and spread around until the whole region was enveloped, and the light of day was entirely excluded. The darkness was the more terrific, being made visible by an awful glare from streams of red and blue light, variously combined through the action of the fires of the pit and the flashes of lightning above. Soon followed an immense volume of sand and cinders, which were thrown to a great height, and came down in a destructive shower for many miles around. A few of the forward company were burned to death by the sand, and all of them experienced a suffocating sensation. The rear company, which was nearest the volcano at the time, suffered little injury, and after the earthquake and shower of sand had passed over, hastened on, to greet their comrades ahead, on their escape from so imminent peril. But what was their surprise and consternation, to find the centre company a collection of corpses. Some were lying down, and others were sitting upright, clasping with dying grasp their wives and children, and joining noses (the mode of expressing affection,) as in the act of taking leave. So much like life they looked, that they at first supposed them merely at rest, and it was not until they had come up to them and handled them, that they could detect their mistake." Mr. Dibble adds, "A blast of sulphurous gas, a shower of heated embers, or a volume of heated steam, would sufficiently account for this sudden death. Some of the narrators who saw the corpses affirm, that though in no place deeply burnt, yet they were thoroughly scorched."

† Polynesian Researches, vol. iv., p. 211.

‡ Mr. Ellis, and many that have followed him in describing Kilauea, make much use of the word "flames," as though flames were actually seen. It is an excusable mistake, where the scenes are so startling and so far beyond description. An account appeared in a public print at Honolulu, about the time of the arrival of the squadron, in which "flames" were called in to give vividness to the description. It is needless to say that none were seen there by the writer, although the condition was the same as for the month previous.

features as when visited by the Expedition. The black ledge continued completely around the crater, and was "three or four hundred feet" above the bottom. The pit was, however, in a more active state: for the southwest and northern parts are represented as vast floods of lava, and there were fifty-one small cones with craters, twenty-two of which gave out vapors, and some ejected lavas. Ellis remarks that the crater appeared as if, a short time before, the lavas had been as high as the black ledge.

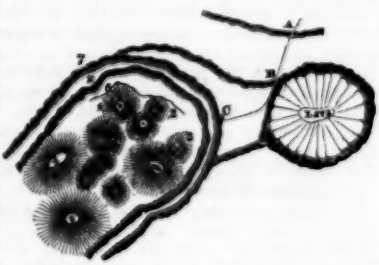
In June, 1832, an eruption took place both from Kilauea and the summit crater of Mt. Loa. The only eruption, at this time, of the lavas of Kilauea to the surface, of which we have definite account, occurred in the east wall of the crater. A deep fissure was opened in the wall, (near *p*, figure on page 352,) from which streams flowed out, part back into Kilauea down the steep slope, and part across into the "Old Crater" (*r*), which, at the time, was overgrown with wood. It is important to trace out, as far as we are able, the changes which preceded it.

a. The first published account of the crater subsequent to Ellis's, is that of the Rev. C. S. Stewart, who visited it in July, 1825.* He states that it was nearly in the condition represented by Ellis in 1823. The bottom was several hundred feet below the level of the black ledge. Fifty-six conical craters were counted, and the action was violent and noisy. A plan of the crater at this time, by Lieutenant Malden, is given by Byron. The black ledge is represented as very much narrower than at present, so that the lower pit occupied nearly the whole width of the crater: the height of the ledge is stated at four hundred feet. The plan represents numerous cones over the bottom, and the two largest occupy together the whole transverse diameter of the crater, which would give for each a diameter of three thousand feet or more at base.†

---

* Journal of a Voyage to the Pacific Ocean, and Residence at the Sandwich Islands, in the years 1822–1825, by C. S. Stewart; 12mo, 1828. New York. p. 355.

† A reduced copy of Lieutenant Malden's plan is annexed, as it will give increased interest to the facts observed by the Expedition. A, is a cliff of eighty feet; B, a cliff of one hundred and fifty feet; C, Lord Byron's encampment; E, the point on the black ledge where they descended to the bottom; 1, the crater in action visited by Lord Byron; 2, a sulphur cone; 3, crater that broke out at the time of the visit, 29th of June; 4, crater brilliantly in action; 5, the largest crater; 6, a deep fissure; 7, deepest and most precipitous part of crater. The whole crater is not represented. The largest cone (5) is nearly half the diameter of the lower pit, and must have been three or four thousand feet in breadth.



b. In December of the same year, Rev. A. Bishop observed that the crater had filled up much since the visit he made with Mr. Ellis, and he estimates the amount of change as four hundred (?) feet. There were a large number of cones "fifty to one hundred feet high," besides lakes boiling with much agitation, "every now and then sending forth a gust of vapor and smoke, with great noise." He adds, "the natives remarked that after rising a little higher the lava will discharge itself, *as formerly*, towards the sea *through some aperture under ground.*"*

c. In October of 1829, Rev. C. S. Stewart made a second visit to the crater, and found, as he states, that the lower pit, instead of being four or five hundred feet deep, as when he before saw it, was but two hundred feet. He remarked that it had filled up at least two hundred feet. It was more quiet than in 1825, but there were still several boiling lakes of lava, and some cones in great activity.†

d. In September of 1832, when the Rev. J. Goodrich visited Kilauea, the eruption had taken place.‡ He says that every thing had changed. The lavas, which previously had increased so as *to fill up to the black ledge, and fifty feet above*, about nine hundred [four hundred?] feet in all, had sunk down again nearly to the same depth, leaving, as usual, a boiling cauldron at the south end. The earthquake of *January preceding* had rent in twain the walls of the crater, on the east side, from top to bottom, producing seams from a few inches to several yards in width, from which the region between the two craters was deluged with lava. About half way up the precipice there was a rent a quarter of a mile in length, from which immense quantities of lava boiled out directly underneath the hut formerly occupied by the party of Lord Byron. The position of Byron's hut is seen at C, on the figure at the foot of the preceding page, and near *p*, on the figure on page 352.

From these accounts, it is probable that in addition to the ejections from the east wall, which are insufficient to account for the subsidence in the lower pit, there must also have been a subterranean outlet beneath the sea, as the native with Mr. Bishop had predicted. This elevation of the lava a thousand feet above the lower pit, with its discharge from the very wall of the crater, is worthy of special note.

The next eruption to that of 1832, was the one already referred to, that commenced on the 30th of May, 1840, the lavas of which, where they reached the sea, were in some places still hot when visited by the author in the November following.

---

* Missionary Herald, xxiii, 53.
† Visit to the South Seas, 2 vols. 12mo. New York, 1831.—ii, 78.
‡ American Journal of Science, xxv, 199.

The only published accounts of the crater subsequent to that just mentioned by Mr. Goodrich, and previous to this eruption, are those of Mr. Douglass,* Captain E. G. Kelley, (from statements by Captains Chase and Parker,)† Count Strzelecki,‡ and Captain John Shepherd.§

a. Mr. Douglass was at Kilauea in January, 1834. The pit, by his measurements, was one thousand feet deep, and the black ledge and lower pit appear to have been in the same condition as when seen by Mr. Bishop. There was a lake of boiling lava in the north end, three hundred and nineteen yards in diameter, besides the large one in the south end. The movement of the lavas to the southward (a consequence of the ebullition) was estimated to have a velocity of three and one-fourth miles per hour.

b. Captains Chase and Parker visited the crater in 1838, four years after Mr. Douglas. At that time, as the sketch made by them on the spot indicates, the lavas had so increased that the lower pit was almost obliterated, the bottom having risen nearly to a level with the black ledge. This will be understood from the figure on page 352: all the bottom pit between $p\,n$ and $p'\,n'$ had become filled up, by the successive overflowings, to within forty feet of the top, and over the four square miles of area, the fires were in great activity. There were six boiling lakes of lava, and twenty-six cones from twenty to sixty feet high, eight of which were throwing out cinders and red hot lava. Standing by the side of one of these lakes, they looked down more than three hundred feet upon its agitated surface: "after a few minutes the violent struggle ceased, and the whole surface of the lake was changed to a black mass of scoria; but the pause was only to renew its exertions, for while they were gazing at the change, suddenly the entire crust which had been formed commenced cracking, and the burning lava soon rolled across the lake, heaving the coating on its surface like cakes of ice upon the ocean surge. Not far from the centre of the lake was an island which the lava was never seen to overflow." These interesting facts illustrate several points of special importance in volcanoes, viz. (1) The rapidity with which lava cools; (2) The frequent rise of temperature that takes place even in boiling lakes, arising from a new gushing from the source below; (3) the formation of clinkers, well compared to the breaking up of ice. From the account of Captain Kelley, it appears that the whole bottom of the crater was not in fusion. On the contrary, the greater part was black lava, over which they travelled to the brink of some of the pools;

* Jour. of the Roy. Geog. Soc., vol. iv.

† American Journal of Science, xl, 117; with a drawing of the crater, which shows that the obliteration of the lower pit was nearly complete.

‡ Hawaiian Spectator, i, 436.

§ Athenæum, Nov. 14, 1840; Roy. Geog. Soc. of London, 1840. Captain Shepherd evidently misunderstood the mode of action at the crater.

yet at times floods of lava covered a large portion of the whole area. The pools were in violent agitation, and "hissing, rumbling, agonizing sounds, came from the depths of the dread abyss."

c. When seen by Count Strzelecki in the same year, it was still in the condition above described. There were six lakes, one, as he states, of 300,000 square yards area, and five of about 5,700 square yards each. The great lake was in violent action.

d. Captain Shepherd was at the crater, Sept. 16, 1839. There were "numerous small cones, twenty to thirty feet high," "lakes of molten matter in violent agitation," besides a "great lake," one mile long and half a mile broad. The party, (notwithstanding the activity, be it observed,) *descended into the crater*, and visited several of the cones and small lakes on their way to the great lake. This lake was in "violent ebullition," underwent constant changes of brightness, and in some places flowed on, "leaving ridges of scoria on the northern shore."

e. We learn from the natives, that, for a week previous to the outbreak, the whole interior was a fearful scene of fiery deluges and ejections. There was no black ledge; for the lavas, by their overflowings, since 1832, had not only filled up the central pit, but accumulated over the ledge, and all was one vast theatre of intense action. The mountain was thus charged. The pressure on the sides below from the lavas and confined vapors had become immense. As a natural consequence fissures opened, and the lavas were drawn off; the centre of the great pit consequently sunk down three hundred and fifty or four hundred feet, which was its condition when visited by us.

There was no great earthquake, no shaking of Mount Loa. At Hilo not the faintest rumbling was heard or felt; and only slight quiverings to the south. It was a simple tapping of the great cauldron, Kilauea; and after it, the crater became comparatively inactive. Its black hardened surface, and the one or two boiling pools which remained over the vast area, exhibited the subdued quiet of exhaustion.

The first appearance of the lavas at the surface occurred in a small crater called *Arare*, about six miles from Kilauea, A, (map on p. 349,) as was ascertained soon after by the Rev. T. Coan.* The light was seen at a distance; but there were no inhabitants living in that vicinity, and it was set down for a jungle on fire. The next day another outbreak was distinguished farther towards the coast; and general alarm prevailed among the natives, now aware of the catastrophe in progress. Other openings followed, and by Monday, the first of June, the large flow had begun

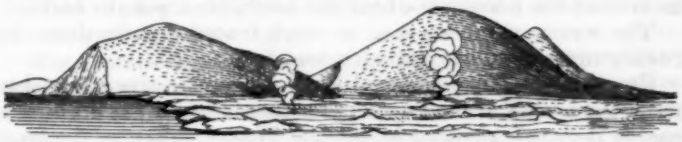
* Missionary Herald, 1841, volume xxxviii, p. 283. The author was over the portion of the eruption towards the sea in November. Subsequently it was examined by Captain Wilkes, Mr. J. Drayton, and Dr. C. Pickering; and by means of their investigations a map of the region was made out.

that formed a continuous stream to the sea, which it reached on the third of June, destroying the small village of Nanawale. This flood issued from several fissures along its whole course, instead of being an overflow of lavas from a single opening; it started from an elevation of 1244 feet, as determined by Captain Wilkes, at a point twenty-seven miles distant from Kilauea, twenty-two miles from the first outbreak, and twelve from the shores. The interval between the first appearance of the lavas and this flood presents a few patches of ejections, and some steam fissures.

The extent of these patches was not accurately ascertained. Dr. Pickering mentions one small one, just before the last outbreak; and another, much larger, (*n*) covering probably three or four square miles, was observed by him a short distance above. A still larger patch, (*m*) according to a native report, exists about half way from the "Big Crater" (C) and the last outbreak; while still another, on the same authority, was seen just north of the "Big Crater." It is very remarkable, as stated by Dr. Pickering, that the line of fracture and lava patches should have cut through a high hill just north of the "Deep Crater" (B), and thus avoided this large pit where it might have been supposed there would have been the least resistance to fracture. The natives state that the lavas rose to a height of three hundred feet in the pit-crater Arare, the first point of outbreak, and then sunk again when the next outbreak took place; and the appearance of scoria within the crater satisfied Dr. Pickering that the lavas had risen at the time to the height mentioned.

The scene of the flowing lavas, as affirmed by those who observed it, beggars description. As we learn from an eye-witness, the lavas rolled on, sometimes sluggishly, and sometimes violently, receiving at times fresh force from new accessions to the fiery stream, and then almost ceasing its motion. It swept away forests in its course, at times parting and enclosing islets of earth and shrubbery, and at other times undermining and bearing along masses of rock and vegetation on its surface. Finally it plunged into the sea with loud detonations. The burning lava, on meeting the waters, as Mr. Coan states, was shivered, like melted glass, into millions of particles, which were thrown up in clouds that darkened the sky, and fell like a storm of hail over the surrounding country. "Vast columns of steam and vapors rolled off before the wind, whirling in ceaseless agitation, and the reflected glare of the lavas formed a fiery firmanent overhead. For three weeks this terrific river disgorged itself into the sea with little abatement. Night was converted into day on all eastern Hawaii. The light rose and spread like the morning upon the mountains, and its glare was seen on the opposite side of the island. It was distinctly visible for more than one hundred miles at sea; and at the distance of forty miles fine print could be read at midnight."

At three spots on the coast, probably over three opened fissures whence lavas issued, the sands continued to be thrown up, until as many rounded or nearly conical elevations were formed, the largest of which was found to be 250 feet in height, and the smallest about 150 feet. They consist of a finely laminated tufa, like tufa craters. The coast is said to have been extended nearly a quarter of a mile beyond its former limits.



TUFA HILLS, NANAWALE.

The stream, as it appeared in November, consisted in its different portions of all the kinds of lava tracts elsewhere observed. In some portions, especially the upper, there were fields of the smoother variety, (the pahoihoi,) with the usual ropings and twistings of the surface; and there were some miniature cones, a few yards in height, out of which the lavas spouted for a while after the rest had become quiet. Large tracts were covered with sand; and walking over them, the feet often broke through into steaming chambers, suggesting caution to the traveller. Other large portions consisted of clinkers, a fact which might have been inferred from the description given of the varying rate of the moving lavas. In some portions they were in huge angular blocks; in others in slabs laid with much regularity against one another. There were numerous caverns and fissures still sending up clouds of steam; and in many, the rocks were yet glowing within a few feet of the surface. A piece of paper was instantly ignited. Small sulphur-banks, with deposits of alum and other salts, were met with in several places.

The islets of forest trees in the midst of the stream of lava were from one to fifty acres in extent, and the trees still stood and were sometimes living. Captain Wilkes describes a copse of bamboo which the lava had divided and surrounded; yet many of the stems were alive, and a part of the foliage remained uninjured.* Near the lower part of the flood, the forests were destroyed for a breadth of half a mile either side, and were loaded with the volcanic sand; but in the upper part, Dr. Pickering found the line of dead trees only twenty feet wide. The lavas sometimes flowed around stumps of trees, and as the tree was gradually consumed, it left a deep cylindrical hole, sometimes two feet in diameter, either empty or filled with charcoal.† Towards

* Narrative Exp. Expd., iv, 184.

† Similar facts to those here stated were observed by M. Bory de St. Vincent at the Isle of Bourbon.—*Voyage aux Isles d'Afrique*, 3 vols., 4to, Paris, 1804.

the margin of the stream, these stump-holes were innumerable, and in many instances the fallen top lay near by, dead but not burnt. Dr. Pickering also states that some epiphytic plants upon these fallen trees had begun again to sprout. The rapidity with which lava cools is still more remarkably shown in the fact that it was found sometimes hanging in stalactites from the branches of trees; and although so fluid when thrown off from the stream as to clasp the branch, the heat had barely scorched the bark.

The waters of the sea were so much heated that the shores for twenty miles were strewed with dead fish.

From the period, thirty-six hours, which the lavas required to reach the sea, an average velocity of four hundred feet an hour is readily deduced, as stated by Captain Wilkes. Yet, as the lavas issued from various fissures along the course,* the result cannot be correctly compared to an *overflow* of fluid: it is rather the rate of progress of the eruption than of the motion of a flowing liquid.

The thickness of the stream of lava here described was estimated by Dr. Pickering as averaging ten or twelve feet. In some places it was not over six feet. The whole area, judging from the surveys, covers about fifteen square statute miles; and reducing to feet and multiplying by the depth, 12 feet, gives for the amount of ejected lava 5,018,000,000 cubic feet; to which, if we add for the previous ejections of the same eruption three more square miles it gives 6,023,000,000 of cubic feet for the whole amount of lavas which reached the surface.†

We have a still more accurate means of estimating the amount of lavas which passed from Kilauea, in the actual cubic contents of the emptied pit. The area of the lower pit, as determined by the surveys of the Expedition, is equal to 38,500,000 square feet. Multiplying this by 400 feet, the depth of the pit after the eruption,‡ we have 15,400,000,000 cubic feet for the solid contents of the space occupied by lavas before the eruption, and therefore the actual amount of the material which flowed from Kilauea. This is two and a half times the amount obtained from the estimated extent of the eruptions. The difference may be accounted for partly on the ground that fissures were filled as well as surfaces overflowed, and also that there may have been eruptions beneath the sea not estimated. This amount is equivalent to a triangular ridge eight hundred feet high, two miles long, and over a mile wide at base.

* On this point we cite the following passage from the Narrative by Captain Wilkes, (iv, 184):—"There are many fissures along the whole line, as will be perceived by the dark places on the map. I feel confident that from each of these an ejection had taken place, and that the lava had in some cases flowed in a contrary direction to the general course of the stream."

† Allowing an average depth of but ten feet, the calculation would give for the whole amount 5,000,000,000 cubic feet.

‡ As the measurements of the Expedition were made eight months after the eruption, we have allowed somewhat for the increase during that time, and also for cavities emptied beneath the ledge.

The lava of the eruption is remarkable for the large proportion of chrysolite, amounting in some parts to nearly one half, and occurring in coarse grains often a fourth of an inch thick. It is consequently very brittle, slabs being easily shattered to pieces by a tap of the hammer. The sands of the seashore produced by the eruption, consist largely of this mineral mixed with black grains of the comminuted lavas. In the abundance of chrysolite the lava is very unlike that formed in the crater either previous or subsequent to the eruption.

The sand-hills are examples of elevations thrown up suddenly over fissures of eruption. They consist of tufa of a rusty yellow color, and are distinctly and finely laminated. The sea is already encroaching on them, and has exposed the regular stratification of the interior, showing a steep inclination of the layers outward. Not a trace of tilting took place in the rocks beneath; they are simple cones of eruption, formed of ejected cinders. The sands are said to have been thrown out from the centre of each hill, while in progress; yet there is now no cavity at top. It appears that the action of the molten lavas as they met the sea must have been like the effect from a furnace of melted glass plunged beneath water. There was a violent explosion and eruption of fragments and steam, which fell around the centre of action; and owing to the water which ascended and descended with them, the structure became laminated like the alluvium of a river. Thus three "Monte Nuovos" instead of one were thrown up at a single eruption. The yellow color of the tufa is owing to the action of the steam and water on the ferruginous cinders, reducing some part of the iron to a hydrate.

Since leaving the Sandwich Islands, I learn from the Rev. Mr. Coan that the crater has again been gradually filling up. In November, 1841, there was little action except in the great lake. In February, 1842, the same condition of things continued, with only an increased state of activity. In July, 1844, Mr. Coan was near when the large lake overflowed its margin on every side, spreading out into a vast sea of fire, filling the whole southern part of the crater as far as the black ledge on either side, and obliterating the outlines of the cauldron. Two deep fissures opened, one on either side under the black ledge, and nearly encircled the whole southern area. The precipitous sides of one were two hundred feet in depth. These fissures soon became filled with the flood that was pouring over from the lake; and in one place "it fell in a cascade of fifty feet, producing a scene of terrific sublimity." In a letter dated June 25, 1846, Mr. Coan states that "the great lake is intensely active most of the time. The repeated overflowings have elevated the central parts of the crater 400 or 500 feet since 1840, so that some points are now more ele-

vated than the black ledge." In a letter written in the next month to a friend from Rev. Mr. Lyman, the crater is described as having the whole interior filled, with some parts of the centre standing 100 to 150 feet above the black ledge. The large lake was still the centre of greatest activity.

It appears then at the last mentioned date to have been nearly in the condition sketched and described by Captain Kelley in 1839, previous to the eruption of 1840, except that the action had not reached the same degree of intensity.

Through a letter from Lieut. Henry Eld, U.S.N., we learn that in the spring of 1849, the bottom of the crater was still as last reported, but more raised. Yet instead of an increase of action, the crater was unusually quiet. The lavas had subsided in the great lake and it seemed as if the fires were in process of extinction. The action was far less than in 1840, when Lieut. Eld was at the crater with the officers of the Exploring Expedition.*

We conclude at this time with a mention of one or two deductions from the facts mentioned.

1. *Frequency of Eruptions.*—The last three eruptions of Kilauea have taken place in a period of nineteen years, or with intervals of eight or nine years. Between the years 1789 and 1823, there may have been a season of comparative quiet, as we learn from the natives of no great eruption. This evidence, however, is by no means decisive. They say, in general terms, that eruptions have taken place during all their kings, and assert that the crater has been in action from time immemorial. It is quite possible that in the above mentioned interval, there were submarine eruptions, if not subaërial; and very probably, the latter also may have taken place. The statement of the native to Mr. Bishop that the lavas, after reaching a certain height, would flow out as *they had formerly done under the sea*, is evidence that they were aware of this mode of emptying Kilauea of its lavas. In six years after 1840, the lower pit was again filled, and since then an eruption has been looked for.

2. *Phases of Volcanic Action.*—There can be no truth, at least as regards Mount Loa, in the principle reasoned out at length, in an able article on volcanoes, by Bischof,† that the phases of volcanic action depend on water gaining access to the central fires of the globe; for the evidence is certainly conclusive that the main action of waters is comparatively near the surface.‡

The phases of volcanic action at Kilauea are as follows:—

The centres of action, when most quiet, are reduced to a single one, which occasionally overflows. This overflowing

* The papers have since reported an eruption, but I have not seen the report confirmed.

† *Natural History of Volcanoes*, by G. Bischof. Jameson's Edinburgh Journal, xxvi, 1839; American Journal of Science, xxxvi, 249, 250.

‡ We omit here the arguments on this point.

raises the bottom of the crater; the lavas continue to boil over, and go on accumulating, and elevating the area of action; the pressure is consequently gradually increasing; the action becomes after a while more intense, perhaps in part from the increasing pressure, and the increasing height to which vapors ascend before escaping; new centres of ebullition add to the effect; finally, after the bottom is raised 400 or 500 feet above its lower level, these centres are numerous, the ebullition is violent, the overflowings almost incessant;—at last the increased pressure, in addition to the force of rising vapors proceeding from the increased action, cause a rupture through the mountain's sides and the lavas flow out.

This is the history from a period of quiet to one of greatest activity. If the larger pool, after an eruption, should become crusted over, as happens with the smaller pools, the lava sinking far below the surface, there would seem to be a state of inactivity. But the same process going on, the surface would be gradually reached, and the work would be continued as above explained. This is mainly a result of the passage of vapors from below, inflating the lavas as they ascend, producing the appearance of ebullition, and occasioning thus the rising of the molten material, and the overflowings. The scoria is the froth of the surface still more inflated, like the scum on the surface of a boiling syrup. Lavas from fissures in Kilauea usually are not scoriaceous, while the overflowings of the lakes have a crust of scoria 4 to 10 inches thick.

To compare Kilauea with other craters, we must keep in mind this important point, proved by the absence of cinders in the crater, and the free ebullition there, that the lavas are remarkably liquid, while those of other craters are comparatively viscid. The ejections of the great lake of Kilauea are 60 feet in height, while those of Vesuvius during an eruption may be 10,000 feet; and this, though not a direct measure of their relative liquidity, is a consequence of it. With this principle in view, we may translate the language of Kilauea into that of Vesuvius or Etna. The phases of their craters may be of the same general nature, and be due to a similar mode of action, varied only by the simple fact of the greater or less viscidity of the lavas. There may be the same succession of effects with the same results; and periods of quiet and violent action may have the same mutual relations and dependence. We need look to no extraordinary influx of waters to occasion an eruption, as the eruption is a result of a progressive state of things, perhaps long in action. I do not here deny that such a paroxysmal influx of waters may at times take place, and has produced results. I urge only that they are exceptions; and that phases of quiet and violent activity would necessarily succeed one another without such intervention.

The same gradually acting cause will also produce occasional violent ruptures. For where the waters for a period find slow access to any centre of heat within the volcanic mountain beneath its cover of rocks, the vapors will gradually accumulate till the pressure breaks a way through the mountain, to give exit to the vapors together with the compressed lavas. The starting of a cork from a bottle of soda water and the escape of the liquid as well as carbonic acid gas, though a familiar incident, depends on a general principle, with regard to pressure, to which even the lavas of a volcano must be obedient. The sudden outburst of lavas through fissures in the very summit of the walls about Kilauea may be of this character. In many cases violent earthquakes should attend this mode of action.

Art. XXXVI.—*On the Chemical Equivalents and Notation of Laurent and Gerhardt;* by Charles Gerhardt.

(Translated for this Journal, from the Comptes Rendus des Travaux de Chimie, Jan., 1849, by T. S. Hunt.)

In commencing the fifth year of these Comptes Rendus, in which I shall have for the future, the collaboration of M. Laurent, I wish to recall the principal features of the notation which we adopt in our system, and which appears to us at the same time more simple and more precise than the dualistic method. * *

The numerical value of our symbols is for the *metalloids*, the same as in the notation of Berzelius, but for the *metals*,* it is only one half. Thus we write, H^2O, SO^2, SO^3, P_2O_5, CO, CO^2, etc.; HCl, HBr, NH_3, have likewise the same significance, as in the ordinary notation: but in the metallic combinations, the symbol of the metal has but one half the value assigned to it in the Berzelian formulas.†

---

* Except for arsenic, antimony, bismuth and uranium, which have the same value as in the Berzelian formulas.

† It will be recollected that the notation of Berzelius as followed by the French chemists, differs a little from that generally employed by the English and German writers. Berzelius, from a consideration of their combining volumes, was led to admit that oxygen and hydrogen unite to form water in the proportion of 1:2, and consequently to write the formula of the compound, H_2O. In accordance with this, he divided also the equivalents of the so-called halogen elements, chlorine, bromine and iodine, and designated the atom of hydrochloric acid, corresponding to water, by H_2Cl_2; his equivalents of nitrogen, phosphorus, arsenic, antimony, etc., are also one half those of the English chemists, but while admitting the atomic composition of water to be H_2O, he conceived the true equivalent of hydrogen to be *a double atom*, and thus made H_2 equivalent with K, Zn, etc. MM. Gerhardt and Laurent have divided in the same way the equivalents of the metals proper, making H the equivalent of K, Zn, etc.—*Translator.*

Examples.	*Notation of Berzelius.*	*Our notation.*
Sulphuret of hydrogen,	H_2S	$S(H_2)$
Sulphuret of potassium,	KS	$S(K_2)$
Chlorid of hydrogen,	H_2Cl_2	$Cl(H)$
Chlorid of potassium,	KCl_2	$Cl(K)$
Sulphuric acid,	SO_3, H_2O	$SO_4(H_2)$
Sulphate of potash,	SO_3, KO	$SO_4(K_2)$
Bisulphate of potash,	$SO_3, KO + SO_3, H_2O$	$SO_4(HK)$
Sulphate of zinc and potash,	$SO_3, KO + SO_3, ZnO$	$SO_4(ZnK)$
Nitric acid,	N_2O_5, H_2O	$NO_3(H)$
Nitrate of potash,	N_2O_5, KO	$NO_3(K)$

The principal difference consists in the notation of *salts*, which we regard as unital in their constitution, as systems in which the metal may be exchanged for another, without affecting the arrangment of the molecular structure. (We write generally the metal in parentheses.) According to this view, the *acids*, properly called, (the hydrated oxacids, and the hydracids,) are *salts*, in which the metal is represented by hydrogen; the oxyds and sulphurets have the same claim to the title of salts as the sulphates and nitrates. The so-called anhydrous acids we look upon as a peculiar class of bodies, (*anhydrids*,) which become acids by the fixation of the elements of water.

We farther assume that *one and the same body may have two or several equivalents.* According to us the idea of an *equivalent* implies that of a similarity of function, and it is known that one and the same element is often capable of playing the part of two or of several other very different elements; it may then happen that each one of these different functions corresponds to different proportions of the first element. On the other hand, we sometimes see different weights of the same metal, as, for example, iron, copper or mercury, replace the hydrogen of acids to form salts, which although containing the same metal, are different in their properties. The metals have then different equivalents. Some examples will make this important proposition more plain.

The ferrous and ferric sulphates are two salts which contain for the same quantity of oxygen and sulphur, different quantities of iron. If we express by S = 16, the quantity of sulphur, by O = 8 that of oxygen, and by Fe = 28 the quantity of iron, we shall have,

Ferrous sulphate,	SO_4Fe	=	SO_3, FeO	} Berzelian
Ferric sulphate,	$SO_4Fe^2_3$	=	$3SO_3, Fe_2O_3$	} formulas.

Thus in the ferric sulphate there are but two-thirds the quantity of iron which exists in the ferrous sulphate; but these two-thirds of Fe are the equivalent of H, K, Na, Zn, etc., and also of the Fe in the ferrous salts; but when two-thirds of Fe replace H in sulphuric acid, or K in the sulphate of potash, we obtain a salt which without ceasing to be a neutral sulphate, possesses properties very different from those of the ferrous sulphate where Fe

entire, replaces H, K, Zn. The equivalent $Fe\frac{3}{3}$ then communicates to the sulphatic system properties as different from those of the ferrous sulphate, as would be those of a sulphate containing any other metal.

Again, in the mercurous and mercuric chlorids we have the same amount of chlorine united to different quantities of the metal.

Mercurous chlorid,	$Hg_2\,Cl_2$	} Berzelian formulas.
Mercuric chlorid,	$Hg\,Cl_2$	}

Hg_2 in the mercurous salts is the equivalent of H, K, Na, Pb, etc., and equally of Hg in the mercuric salts. Mercury has then according to our view, two equivalents (*mercuricum* and *mercurosum*), as compared with other metals, which are to each other as 1 : 2, and each one of these has its peculiar properties.

To show in the formulas that $Fe\frac{3}{3}$, Hg_2, represent equivalents of H, K, Na, etc., we often replace the exponents by certain signs, employing the Greek letters α, β, γ, and δ, in place of the numbers 2, $\frac{3}{3}$, $\frac{1}{2}$, $\frac{1}{3}$. The equivalents of H in the following salts are then thus represented.

$2 = \alpha$

Cu in the cupric salts.	Cu_2 or $Cu\alpha$ in the cuprous salts.
Hg " mercuric "	Hg_2 or $Hg\alpha$ " mercurous "

$\frac{3}{3} = \beta$

Fe in the ferrous salts.	$Fe\frac{3}{3}$ or $Fe\beta$ in the ferric salts.
	$Al\frac{3}{3}$ or $Al\beta$ " aluminic "
Cr " chromous salts.	$Cr\frac{3}{3}$ or $Cr\beta$ " chromic "
Mn " manganous "	$Mn\frac{3}{3}$ or $Mn\beta$ " manganic "

$\frac{1}{2} = \gamma$

Sn " stannous salts.	$Sn\frac{1}{2}$ or $Sn\gamma$ in the stannic salts.
Pt " platinous "	$Pt\frac{1}{2}$ or $Pt\gamma$ " platinic "

$\frac{1}{3} = \delta$

	$Bi\frac{1}{3}$ or $Bi\delta$ in the bismuthic salts.
	$Sb\frac{1}{3}$ or $Sb\delta$ " antimonic "
	$Au\frac{1}{3}$ or $Au\delta$ " auric "

Upon this plan of notation we write the formulas of these salts as follows:

	Berzelian notation.	*Our notation.*
Alum,	$SO_3, KO + Al_2O_3, 3SO_3 + 24$ aq.	$SO_4(K\frac{1}{3}\,Al\frac{3}{2}) + 6$ aq.
Sulphate of potash,	SO_3, KO	$SO_4(K_2)$
Phosphate of soda,	$P_2O_5, 2NaO, H_2O + 24$ aq.	$PO_4(Na_2H) + 12$ aq.
Biphosphate of soda,	$P_2O_5, NaO, 2H_2O + 2$ aq.	$PO_4(NaH_2) +$ aq.
Phosphate of lead,	$P_2O_5, 3PbO$	$PO_4(Pb_3)$
Phosphate of alumina,	P_2O_5, Al_2O_3	$PO_4(Al\frac{3}{3})$

The simplicity of the new notation is especially evident when applied to those salts which contain several metals, as in the natural silicates. Take for an example the formula of the chlorite of Slatoust, which in the notation of Berzelius is represented by

$$3MgO, SiO_3 + Al_2O_3, SiO_3 + 2(MgO, 4H_2O).$$

This we write,

$$SiO_3\,(Al^{\beta\frac{2}{3}}\,Mg^{\frac{5}{3}}\,H^{\frac{4}{3}}),$$

and this formula reminds us at once that chlorite belongs to the silicates of the form $SiO_3\,(M_4)$,* for $\frac{2}{3}+\frac{5}{3}+\frac{4}{3}=4$.

The advantage of our notation consists then principally in this, that it expresses all the salts of the same genus in the same manner; each symbol appears but once in a formula. Consequently *we denote similar compounds in a similar manner.*

In the notation of organic substances, we take their volumes into consideration, when they are bodies which are volatile without decomposition. We denote these always by the same number of volumes, and the non-volatile compounds derived from them by similar formulas. Thus for the monobasic acids, we take as an equivalent the quantity which contains (H) one equivalent of basic hydrogen; this corresponds to two volumes of vapor. The derivatives (*non binômes,*) which do not perform the functions of salts, are represented by the same number of volumes; in case these derivatives are fixed, we take as an equivalent the quantity produced by one equivalent or yielding one equivalent, of the monobasic acid. For example,

	Berzelian notation.	*Our notation.*
Acetic acid, . .	$C_4H_6O_3, H_2O$	$C_2H_3O_2(H)$
Acetate of potash,	$C_4H_6O_3, KO$	$C_2H_3O_2(K)$
Ferric acetate, . .	$3C_4H_6O_3, Fe_2O_3$	$C_2H_3O_2(Fe^{\beta})$
Chloracetic acid, .	C_2O_3, C_2Cl_6, H_2O	$C_2Cl_3O_2(H)$
Chloracetate of potash, .	C_2O_3, C_2Cl_6, KO	$C_2Cl_3O_2(K)$
Ferric chloracetate,	$3(C_2O_3, C_2Cl_6), Fe_2O_3$	$C_2Cl_3O_2(Fe^{\beta})$
Alcohol, . . .	C_2H_6O	C_2H_6O
Aldehyde, . . .	$C_4H_8O_2$	C_2H_4O
Olefiant gas, . .	CH_2	C_2H_4

The bibasic acids not being volatile without decomposition, the law of volumes cannot be applied to them directly, but these acids give by decomposition, volatile anhydrids. We take then as the formula the quantity which yields two volumes of an anhydrid. These acids are therefore represented with two equivalents of basic hydrogen (H_2). Examples.

	Berzelian notation.	*Our notation.*
Oxalic acid, . .	C_2O_3, H_2O	$C_2O_4(H_2)$
Oxalate of potash,	C_2O_3, KO	$C_2O_4(K_2)$
Binoxalate of potash,	$C_2O_3, KO + C_2O_3, H_2O$	$C_2O_4(HK)$
Quadroxalate of potash, . .	$C_2O_3, KO + 3(C_2O_3, H_2O)$	$C_2O_4(H^{\frac{3}{2}}K^{\frac{1}{2}})$

* We write silica SiO; $(SiO, 2M_2O, = SiO_3\,(M^4).)$

In the same manner the tribasic acids are denoted with three equivalents of basic hydrogen, (H_3,) as in the following examples.

	Berzelian notation.	*Our notation.*
Citric acid, . .	$3C_4H_4O_4, 2H_2O$	$C_6H_5O_7(H_3)$
Acid citrate of potash,	$3C_4H_4O_4, KO+H_2O$	$C_6H_5O_7(KH_2)$
Second citrate of potash, . .	$3C_4H_4O_4, 2KO$	$C_6H_5O_7(K_2H)$
Third citrate of potash, . .	$C_{12}H_{10}O_{11}, 3KO$	$C_6H_5O_7(K_3)$

By analogy we represent the mineral acids also with H, H_2 or H_3, according as they are monobasic, bibasic, or tribasic.

Most chemists denote organic substances by formulas which are double those adopted by us, but all these formulas, when they are exact, may be divided by two and represented in our notation.

I finish this introduction by a table of the proportional numbers of the principal simple bodies, with the numerical value that is ascribed to them in our notation.

		H=1.	O=100.			H=1.	O=100.
H	Hydrogen, .	1·	6·25	Cl	Chlorine, .	35·5	221·87
Li	Lithium, .	6·4	40·16	K	Potassium, .	39·	243·75
B	Boron, . .	10·8	67·50	Sr	Strontium, .	44·	275·00
C	Carbon, . .	12·	75·00	Cd	Cadmium, .	56·	350·00
Mg	Magnesium,	12·	75·00	Sn	Tin, . . .	59·	368·75
Al	Aluminium,	13·7	85·63	Sb	Antimony, .	64·5	403·25
N	Nitrogen, .	14·	87·50	Ba	Barium, . .	68·	425·00
Si	Silicon, . .	14·	87·50	As	Arsenic, . .	75·	468·50
O	Oxygen, .	16·	100·00	Se	Selenium, .	78·5	490·90
Fl	Fluorine, .	18·6	116·85	Br	Bromine, .	80·	500·00
Ca	Calcium, .	20·	125·00	W	Tungsten, .	96·	600·00
Na	Sodium, .	23·	143·75	Pt	Platinum, .	99·	618·75
Cr	Chromium, .	26·	162·50	Hg	Mercury,	100·	625·00
Fe	Iron, . .	28·	175·00	Pb	Lead, .	104·	650·00
Mn	Manganese, .	28·	175·00	Ag	Silver, .	108·	675·00
Ni	Nickel, . .	29·6	185·00	U	Uranium,	120·	750·00
Co	Cobalt, . .	29·6	185·00	J	Iodine, .	126·	787·50
Cu	Copper, . .	31·8	198·75	T	Tellurium,	128·	800·00
S	Sulphur, .	32·	200·00	Au	Gold, .	196·	1225·00
P	Phosphorus,	32·	200·00	Bi	Bismuth,	210·	1312·50
Zn	Zinc, . .	33·	206·25				

Art. XXXVII.—*The Natural Relations between Animals and the Elements in which they live;* by L. Agassiz.

Among the early attempts to arrange animals in a systematic order, we find almost universally, that the natural elements in which their different tribes live are introduced as the fundamental principle of their classification. During the sixteenth and seventeenth centuries, the great works published upon natural history by Gesner, Rondelet, Belon, Aldrovandi and others acknowledge this as the only basis of their arrangement of the animal kingdom. Even at a later period, when characters derived from the animals themselves, rather than from the external circumstances in which they dwell, had been introduced into our systems, we still find a prevailing influence of such considerations upon the circumstances of the natural subdivisions of animals. As soon however as the study of comparative anatomy had shed its brilliant light upon this question, those views were entirely abandoned, and the whole animal kingdom was finally arranged according to its internal structure. The introduction of this principle was hailed as a new era in the history of our science; and, after Cuvier had applied it to a general revision of the whole animal kingdom, it was and has been universally acknowledged as the only safe foundation of a natural classification of animals.

The recent progress in zoology, and of the various branches of natural history connected with it, has however opened the prospect of further improvements, even upon the basis on which our classification at present rests. For embryology is already displaying its vast influence upon zoological questions, and the time is not far distant, when its share in the natural arrangement of animals will be as large as that of comparative anatomy itself, and when information derived from all possible quarters shall have equally its due influence upon our natural methods. A desire to investigate the various questions bearing upon classification has led me to revise the subject of the natural relations which exist between animals, and the elements in which they live. The connection between animals and the surrounding media in which they live has of late been so entirely disregarded, that it is time to reconsider this question with all the attention its importance demands, since we find in it a decided relation to the structure and functions of all animals. For though it is plain that the mere living in water or upon dry land is in itself of slight importance, as there are so many animals which dwell in the two elements although having the same *identical* structure, it should not be overlooked that the greater number of aquatic animals have structural peculiarities common to all, and that the same is the case

with the terrestrial or aërial animals. For instance, all those which live upon dry land breathe directly the atmospheric air, and have a respiratory apparatus adapted for direct introduction of this element into their systems, while aquatic animals breathe through apparatus of a different structure adapted to a permanent contact with aërated water. This circumstance alone would suffice to show that the natural relations of animals with the elements in which they naturally dwell, is in direct connection with at least some of their structural peculiarities. But there are other circumstances which may lead to the conviction that this connection has not merely reference to the structure of their respiratory apparatus, but influences their whole organization. The greater pressure under which aquatic animals are maintained throughout their life modifies, in many other respects, their organization. In many of them the surrounding element has largely a direct access into the cavities of the body or even into their tissues; so that a direct and universal influence of the surrounding media must be acknowledged throughout the animal kingdom as soon as we take into consideration all their peculiarities. This influence will be appreciated more correctly, if we consider it separately in each great group of the animal kingdom as established upon anatomical evidence.

After removing the Whales from the Fishes, it will be plain that the Cetacea must be considered simply as an aquatic type of the class of Mammalia, and that the connection which exists between them and the element in which they live will not affect at all the views which we shall entertain about that class, and only allow us to consider within more natural limits, the true relation which exists between fishes and the natural element in which they are found. The circumstance that so many birds are aquatic in their habits will no longer prevent us from considering the class of Birds as a most natural group in the animal kingdom, the limits of which are well defined by anatomical evidence; and the relations of aquatic birds to the waters upon which they alight or in which they dive, will only be considered within the limits of a well circumscribed natural group. The same may be said of Reptiles; and the circumstance that so many of their types are almost entirely aquatic, while others are terrestrial, will by no means prevent us from viewing them as a natural class, in which the connection with either main land or the water shall appear as a subordinate feature.

Again the class of Insects, which is so thoroughly aërial throughout almost all its types, at least in their perfect state of development, circumscribed as it is within natural limits upon anatomical evidence, will appear to us as a type which shall bear no relation in our mind to the class of Birds, although their movement through the atmosphere be apparently so similar.

But, although we remove in this manner almost completely the circumstance of animals dwelling either in water or upon main land as influencing in any way our general classification of the animal kingdom, it were a great mistake to lose sight entirely of this most intimate relation among the natural secondary groups of animals under their different types.

The value of these considerations has become more apparent, since the outlines of the leading divisions in the animal kingdom have been made in detail by allowing the results of embryology to have their due share of influence upon our classification; and the object of these remarks is chiefly to show that there is a universal relation throughout the animal kingdom between their structure and gradation and the elements in which they live; that, in all the four great types of the animal kingdom, the aquatic groups stand, in natural classification, lower than the terrestrial, and that this connection is so intimate as to extend even to the subdivisions, and so much so, that I have arrived at the conviction that in an otherwise well defined natural division, the aquatic tribes should be placed below the terrestrial ones; that even in narrowly circumscribed families the aquatic genera rank below the terrestrial, and that even in natural genera the aquatic species are inferior to the terrestrial ones. But before considering those minor divisions let us take a general glance at the four great types of the animal kingdom beginning with the Radiata.

If we consider the type of Radiata as it is still circumscribed in some of our most recent works upon the animal kingdom in general, we may fail to discover this intimate connection between their natural types and the media in which they live. But if we reduce the type of Radiata to those classes which I consider as alone truly representing that type, we shall be at once struck with the remarkable result, that all these animals are aquatic, nay, that, with one single exception, they are all marine. But before this can be acknowledged, it must be shown that the type of Radiata should be reduced to the three classes of Polypi, Jelly-fishes and Echinoderms; and that, among Polypi, there are large numbers of animals now united which do not all belong to that class. The most extensive range acknowledged by some zoologists in the type of Radiata includes Infusoria with the Rotifera and also intestinal worms. Without entering for the present into a full discussion of the natural character of all the animals which have been included in the class of Infusoria, I may limit my remarks to a few critical points, in order to show that the Polygastrica, and even the Rotifera cannot be ranked among Radiata.

In the first place Rotifera constitute a particular group among Infusoria as Ehrenberg himself has acknowledged. They differ so completely from the Polygastrica as to forbid entirely their union in a natural classification. The only question is whether

they can remain among Radiata, and, if not, where they should be placed. There is so little analogy between the structure of Rotifera and the structure of true Radiata, that ever since the beautiful illustration of their forms and structure as given by Ehrenberg, most naturalists and anatomists have felt inclined to remove them to another type of the animal kingdom. Their resemblance to Articulata has appeared to some so striking as to warrant, in their opinion, their removal to the class of Crustacea, among Entomostraca, while others have considered them as more closely allied to worms. But I may say that all, or almost all, naturalists at present understand the necessity of removing them from among Radiata into the great type of Articulata.

This point is no longer in question; the only remaining doubt respecting them is whether they should rank among the lower Crustacea, or among the worms in the wider sense. As for the Polygastrica, we meet with greater difficulties in attempting to classify them; for this group, as understood by Ehrenberg, consists still of most heterogeneous beings which do not even all belong to the animal kingdom. Recent investigations upon the so-called Anentera, including the families of Baccillaria and Volvocine Infusoria, have satisfactorily shown, in my opinion, and in that of most competent observers, that this type of Ehrenberg's Polygastrica without gastric cavities, and without an alimentary tube, are really plants belonging to the order of Algæ in the widest extension of this group; while most of the Monas tribe are merely movable germs of various kinds of other Algæ. As for the other Polygastrica which Ehrenberg combines in this division of Enterodela, I am satisfied that they also constitute still a heterogeneous group belonging to different types of the animal kingdom; and that most of them, far from being perfect animals, are only germs in an early state of development. The family of Vorticellæ exhibits so close a relation with the Bryozoa, and especially with the genus Pedicellina, that I have no doubt that wherever Bryozoa should be placed, Vorticella should follow, and be ranked in the same division with them.

The last group of Infusoria, Bursaria, Paramecium and the like, are, as I have satisfied myself by direct investigation, germs of fresh water worms, some of which I have seen hatched from eggs of Planaria laid under my eyes. This being the case, we see that, without exception, the whole class of so-called Infusoria must be dissolved into its various elements and divided partly among the Articulata, and partly among Mollusca in the widest extension of those groups, (if it can be shown that Bryozoa belongs also to the type of Mollusca,) that large numbers of them belong to the vegetable kingdom, and others are simply germs of other types, and that no single one of them belongs to the type of Radiata.

If we next consider the Polypi we find them constituting another main group and most natural class, to which indeed some heterogeneous types have been annexed; upon the removal of these however that class constitutes a very natural division of the type of Radiata among which they form the lowest class. The natural groups which require to be removed from Polypi are, —first, the so-called Hydroid Polypi, which, though truly radiated animals, do not belong to this class, but are, as I have shown from their structure, and as might long ago have been inferred from their development, true members of the class of Medusæ, among which they constitute a type of stalk animals, as crinoids among star-fishes.*

The Bryozoa also are not constructed upon the plan of Radiata, as has long been shown by Milne Edwards and others. Their true position is among Mollusca, and embryonic investigations upon Ascidia have satisfied me that Bryozoa, compound, and simple Ascidia, form a natural series of well connected types leading to the true Acephala among ordinary Mollusca, among which Bryozoa will form a natural group of compound animals, bearing the same relation to the ordinary bivalve shells, that common corals bear to the simple Actiniæ and Fungiæ. Though the doubts entertained about the Foraminifera among Bryozoa, would not affect at all the points under discussion, I may as well state at once, that I have arrived at the conclusion that Foraminifera constitute the lowest type of Gasteropoda, and exemplify under permanent forms the state of division of their germs in their embryonic development. Thus circumscribed, the class of Polypi constitutes a very natural group containing only animals of an identical radiated structure, the organization of which is at present very satisfactorily known.

The class of Medusæ has been from the beginning so well characterized, and circumscribed within so natural limits, that it has undergone since its establishment only slight modifications by the removal of some few genera: and after the position of the so-called Hydroid Polypi among them shall have been generally acknowledged, I believe it will undergo scarcely any new changes in its extension, though we may still expect extensive improvements, which are indeed very much needed, in the characteristics and internal arrangement of their natural families. Considering their structure, the Medusæ rank immediately above Polypi.

The Intestinal Worms have long been placed among Radiata, and considered as a natural class in this great type of the animal

* See my paper upon the homologies of radiated animals with reference to the classification of the so-called hydroid polypi, read before the American Association for the Advancement of Science, held in Cambridge, August, 1849; also my lectures upon comparative embryology, delivered before the Lowell Institute, Dec., 1848, and Jan., 1849.

kingdom, notwithstanding so many striking differences in the plan of their structure. This position was assigned to them upon the ground of the radiated arrangement of parts around the head, and the vascular form of some of their genera, and also upon the supposed want of a nervous system in all of them. But since the discovery of nerves in all of their types, and since the most intimate relations have been discovered between them and so many other external worms, their complete separation from Annelides as a distinct class is hardly recognized now by any modern investigator. And the necessity of combining the intestinal parasitic worms into one great natural group with the other external free worms is becoming daily more evident to all, so that whatever position be assigned to Annelides in the great type of Articulata, Helminths have to follow them, and must therefore be removed from the type of Radiata. This point is undisputed now, though there may be a difference of opinion as to the propriety of admitting, to one great class, all Worms, or of subdividing them into minor natural groups.

The third class among Radiata is that of Echinoderms, which has been circumscribed within most natural limits since the reunion of Holothuriæ and Crinoids, with the common star-fishes and true Echini. Whoever is familiar with the embryonic development of Echinoderms, which has been extensively investigated of late, will acknowledge an intimate relation between them and the other two classes of Radiata, and not be willing to assent to the proposed separation of Echinoderms as one great type in the animal kingdom, placed upon an equal footing with Mollusca, and will consider their separation from Polypi and Medusæ, as proposed by Dr. Leuckardt, rather as a retrograde step, than as an improvement upon the general classification of animals. To me the type of Radiata, embracing the three classes of Echinoderms, Medusæ and Polypi, constitutes, in its circumscription illustrated above, a most natural group of the animal kingdom, all the members of which are intimately connected by a close uniformity in the plan of their structure, but present a remarkable gradation of their types in the manner in which this structure is developed in each of their classes. And the circumstance that even in the higher ones, which contain chiefly free movable animals, we have some few representatives attached permanently to the soil upon a Polyp-like stalk bearing the radiated animal crown, shows further the intimate connection which exists between them all. Radiata consist therefore of three classes only, which in their natural gradation rank as follows: Polypi, lowest, next, Medusæ, and highest, Echinoderms.

As soon as we have removed in this way all the classes or families which do not strictly belong to the type of Radiata, we cannot fail to perceive at once that all the remaining animals which

must be considered as truly radiate are not only all aquatic, but, with a single exception of the genus Hydra, all strictly marine; from which we are allowed to infer that, in the plan of the creation, the radiated structure is incompatible with a terrestrial mode of life. We see that the lowest degree of development of the whole animal kingdom is entirely marine; and that it has been so throughout all ages in the history of our globe, is shown by the large numbers of Radiata found from the earliest periods through all geological epochs up to the most recent, and the entire absence of radiated animals in any of the fresh water deposits. The circumstance that no single genus among Radiata contains fresh water animals, further shows that this type in its main features is not better adapted for a fluviatile existence; or, we may say in other words, that the plan involved in the structure of radiated animals is chiefly adapted to the sea. We might perhaps even say, if, in this stage of the investigation, it would not seem premature to go so far, that the lower types of animals are not only entirely aquatic, but exclusively marine. The fact of so large a number of aquatic animals as Radiata being so exclusively marine, undoubtedly shows that the connection of organic structure with the ocean, involves peculiar circumstances, which fresh waters by no means afford to a similar extent. Whether this is especially connected with the greater density of the medium or not, I am not fully prepared to say, though I am inclined to believe that it is so, from the circumstance that Radiata are so constantly killed by the contact of fresh water, as I have ascertained by direct experiment upon Polypi, Medusæ and Echinoderms, some of which are struck with almost instantaneous death, when brought into fresh water, and decompose with astonishing rapidity. I have seen on dropping an Ophiura into fresh water, all the articulations dismembered and entirely separated within a few minutes.

No one of the three other great types of the animal kingdom is either so exclusively marine, or even so exclusively aquatic as that of Radiata. For among Mollusca we have quite a number of terrestrial genera, and even a large number of fresh water genera and families.

Among Articulata we notice also large numbers of fresh water species, and a still larger number of terrestrial forms. Finally, among Vertebrata we find the most promiscuous occurrence of marine, fresh water and terrestrial forms. It is now important to ascertain whether we may trace, beyond Radiata, a direct relation between structure and the element in which animals live, and whether the gradation of this structure has any reference to the surrounding media as it unquestionably has among Radiata.

Let us first consider Mollusca, and perhaps revise their classes in a zoological point of view before undertaking the investigation

of their relations to the media in which they dwell, allowing in this revision, a due influence to embryology as far as it can influence this question at present.

The number of classes which should be admitted among Mollusca, is the first point of importance we have to consider. Since the Barnacles or Cirripedia which Cuvier still considered as a class among Mollusca, are now known to belong to the type of Articulata, and to be most conveniently combined with Crustacea, we have five classes of Mollusca left, if we follow Cuvier's arrangement of these animals, as he distinguishes Cephalopoda, Pteropoda, Gasteropoda, Acephala and Brachiopoda, as so many distinct classes of the type of Mollusca in the order of gradation just mentioned. It will hardly be necessary at present to insist upon the close relation which exists between Brachiopoda and the other bivalve shells. Indeed, anatomical investigations of these animals have shown that they are not only constructed upon the same plan, but that the differences between Brachiopoda and ordinary Acephala, are scarcely as great as the differences which exist between Ascidia and Lamellibranchiate Acephala, which Cuvier nevertheless placed in one and the same class. We shall therefore consider Tunicata, Brachiopoda and Diphyra, as one great natural class under the name of Acephala, to which we also refer, as mentioned above, the type of Bryozoa, which has been so long combined with Polypi. As to Pteropoda and Gasteropoda, though they are still generally considered as two classes, we shall, for reasons explained elsewhere,* and from embryological evidence, place Pteropoda below Gasteropoda proper, not as an intermediate type between Gasteropoda and Cephalopoda; for, Pteropoda are rather an embryonic type exemplifying, in a permanent form, that stage of development of common Gasteropoda, when they are provided with large vibracula, and a thin symmetrical shell deciduous in so many of them; bearing to that state of development of the common Gasteropoda the same relation which Foraminifera bear to a still earlier period of their embryonic growth, when the yolk is undergoing its process of gradual successive division, which seems to me to be exemplified in a permanent form in the numerous cells into which the body of Polythalamia or Foraminifera is naturally divided. If this view be correct, the class of Gasteropoda would therefore consist of the three types of Foraminifera, Pteropoda and true Gasteropoda, among which we would place the Heteropoda, lowest, and the Pulmonata highest, both on account of their structure, and on the ground of the peculiar mode of development of Pulmonata.

* See a paper upon the homologies of Gasteropoda and Acephala with reference to the systematic position of Pteropoda, Foraminifera, Brachiopoda and Bryozoa, read before the American Association, &c.

The third class is that of Cephalopoda, which has always been circumscribed within natural limits, since Foraminifera have been removed from it. The position which I ascribe here to Foraminifera will appear very natural to those who are equally conversant with the succession of fossil types in geological periods, and with embryology, and who know, as we have seen it to be the case also among Radiata, that the higher classes reproduce in their lower forms, types analogous to the lower ones. For the great number of fossil chambered shells, existing in earlier geological periods, is very striking when we compare those old representatives of the class of Cephalopoda with their condition in the present period of the creation, and the natural gradation and analogy between Bryozoa as the lowest type of Acephala, with the Foraminifera as the lowest type of Gasteropoda, and the chambered shells of old ages as lower types of Cephalopoda will remind us of similar relations between Polypi as the lowest type of the animal kingdom, the so-called Hydroid Polypi as the lowest type of Acalephæ, and Crinoids as the lowest type of Echinoderms, which are strictly parallel cases in two of the great types of the animal kingdom.

If we now start from these modifications in the classification of Mollusca which rest entirely upon anatomical and embryological considerations, to appreciate the relations between the three classes of this type, and the media in which they naturally live, we cannot fail to be struck with the circumstance, that all Acephala, with one single exception, are aquatic, as are also Cephalopoda; and that we have only terrestrial representatives among Gasteropoda. Next it must be obvious, that among Acephala we have fewer fresh water representatives, than among Gasteropoda, as the fresh water types of Acephala belong truly to two groups one of which has very few fresh water families, whilst among Gasteropoda we have quite a variety of fluviatile and terrestrial types.

The first thing which must strike us in this type, when contrasting it with the Radiata, is the circumstance of a far larger proportion of fresh water forms and of the introduction of a number of terrestrial ones. This simple fact in itself would go to sustain the hint thrown out above, that a higher organization in the animal kingdom is better adapted to the fluviatile and terrestrial life, than a lower structure; as among Radiata we have not one single terrestrial type, and only a single fluviatile one; whilst the Mollusca, the structure of which is formed upon a plan decidedly higher than that of Radiata, present already a large increase of fluviatile types, with the addition of very many terrestrial ones. But this view will at once be sustained to a most unexpected extent if we consider which of the Mollusca are aquatic, and marine, which are fluviatile, and which are terrestrial. Beginning with the Acephala, we have then, in the first place, all the

Polyp-like Bryozoa, and Tunicata, and the compound Tunicata, entirely marine, with the exception of a few genera of fresh water Bryozoa. And it is very interesting to notice that fresh water animals among Mollusca are of the lowest type of their class, as also was the first and only fresh-water Radiate,—showing thus that the types to which they belong are not adapted to rise into any of their higher developments into the forms best fitted for other elements.

Next we notice the Brachiopoda which are all, without exception, marine. Next Lamellibranchiata, mostly marine, though some of their types are fluviatile. So the entire class of Acephala is aquatic and chiefly marine, and its fluviatile types belong to its lowest group, and to its highest. This circumstance has raised the question with me, what is the proper position to assign to the Naiades among the Lamellibranchiata, and upon due consideration of their peculiar characters, and especially of the circumstance that their mantle is entirely open, that they have no prolonged syphons whilst there are such even among Ascidia, I am inclined to suppose that they rank highest among Lamellibranchiata and that Monomyarians should rank between Brachiopoda and Dimyarians. The reason for assigning to Naiades this higher rank rests upon the homology traced between the foot of Gasteropoda and that of Acephala, and between the reduction of the mantle upon the sides of the foot which it no longer encloses in Gasteropoda, and also the higher position of the gills under the margins of the mantle, all peculiarities in which Naiades bear closer resemblance to common Gasteropoda, than any other of the Acephala. Thus this class of Acephala, though chiefly marine, with a few representatives of its lowest types in fresh water, would reach its highest degree of development in one family, which is entirely fluviatile.

Among Gasteropoda we have again Foraminifera as the lowest type entirely and without exception marine; Pteropoda, which rank next, entirely and without exception marine; Heteropoda which follow, equally marine; and among true Gasteropoda, which in their class are decidedly the highest, we find first, fluviatile and then terrestrial families. And now the question is, among these, what is the respective position of the marine families, of the fluviatile families, and of the terrestrial families. There are among them such structural peculiarities as will decidedly settle the question. If we set aside for a moment the few branchiate fresh water Gasteropoda, we have a large number left which are pulmonate, and which live in fresh water and upon land, and which as a whole we may contrast with the branchiate true Gasteropoda, which are almost all marine, with the few exceptions of Valvata and Paludina and Ampullaria. Now which of these two types rank highest will not be a matter of doubt as soon as it is remembered that Phlebenterata are among branchiate Gasteropoda, and

by their general structure, rank below the others. So that we shall have the marine branchiate Gasteropoda follow immediately the Heteropoda to which they are more or less closely allied through the Phlebenterata, and, above all, the Pulmonata. But here arises a new question. This family of Gasteropoda is partly fluviatile and partly terrestrial, and we may further ask, which should rank higher? No one familiar with the forms of these animals will hesitate in answering this question. We need only compare the development of their tentacles, their forms and position, and the development of their organs of sense, to be satisfied that Helices and Limax rank above Planorbis and Limnæa. So that the natural gradation established by their structure among the upper groups in the class of Gasteropoda, agrees with their natural connection with the elements in which they live in the order which I have assigned to these, the types of Gasteropoda which are lowest being exclusively marine; the highest, equally fluviatile and terrestrial; and among these the fluviatile ranking immediately above the marine, and the terrestrial ranking highest, and the proportion of the fluviatile in the whole class being still larger than in the class of Acephala, inasmuch as the structure of Gasteropoda is also a higher degree of development of Mollusca than that of Acephala, and the first terrestrial type in the animal kingdom in the gradation of its structure making its appearance in the class of Gasteropoda.

The Cephalopoda are highest among Mollusca as a class. They rank so high as to rival in the complication and development of their structure even some of the Vertebrata, and strange to say, we have among them only marine types, not a single fluviatile representative, nor a single terrestrial one. This fact would at first seem to be in direct contradiction with the statements made before, if it were not for the circumstance that this class in itself as represented in our days does not seem altogether reduced in comparison with the other two, if we could not be satisfied that its perfect period of development were the former geological ages when its numbers were far greater than at present, a circumstance which places the whole class in peculiar relations to its type, which must be rather appreciated under the point of view of the conditions which prevailed in former ages, when the ocean covered more extensively the whole surface of the globe than at present; so that the type with its high organization must be considered more with reference to its development in former ages, than to what it is now, as at present the class is proportionally reduced, and it is well known, and it will be further mentioned with reference to other types, that in earlier periods however high animals might have ranked by their structure, they were all marine, as we know fishes to have been the only representatives of Vertebrata in earlier periods.

At this stage of the investigation, a comparison between Mollusca and Radiata shows that, though the former advance farther in their fluviatile development, and even reach with some few of their types a terrestrial mode of existence, there is not yet a single family among them which is entirely terrestrial, nor a single class which is either entirely fluviatile or terrestrial, this connection with the higher conditions of existence being only introduced among some few of their representatives, which we are allowed from other data to consider as the highest in their respective groups.

If we now pass to the great group of Articulata and begin as before by revising their zoological arrangements as based upon anatomical and embryonic data, we shall have at the outset to settle the limits of their classes, and their relative positions.

The first point which we have here to investigate is the question whether Articulata in the widest extension of this group constitute one single natural type, or whether they should be subdivided into two equivalent groups, as has been proposed by those who would restore the division of worms, in its widest sense, as a great division equal in zoological importance to the type of Mollusca, and unite the Arthropoda, Crustacea, and Insects to form another group of equal value.

The great diversity among worms, seems at first to warrant in some degree, such an arrangement. But as soon as we consider the metamorphosis which insects undergo, and compare their earliest stages of growth with the structure and forms of worms, we cannot fail to perceive, that notwithstanding the many peculiarities which characterize worms, they are, after all, only one of the permanent modifications of the same type as Crustacea and insects, among which last the characters and forms of a large number of worms are reproduced as transient states of growth; so that upon the most natural view, and especially if we allow embryology to have its due weight in fixing our opinion, we must consider worms with all their diversified forms, Crustacea in all their diversity, and Lepades, Arachnidæ and Insects, to constitute one single undivided natural type in the animal kingdom. Assuming upon the foundation alluded to, and without entering into a detailed argument upon this question, that this is the right view of this subject, the next question is about the number of classes into which these Articulata should be subdivided. Taking here again anatomical and embryological evidence as our guide, and remembering what was said above of intestinal worms we shall find that the most natural combination of the different groups of Articulata will bring them all into three classes, one containing those in which the body is either more or less distinctly articulated, or in which indications of transverse wrinkles in the skin are scarcely marked, or wholly wanting, but in which, however developed these

joints may be, they never combine in such a manner as to divide the body into distinct ridges, in which the form is always elongated and vermiform, never provided with articulated rings, however numerous and diversified the locomotive appendages may be, and in which the foremost joints hardly ever assume a peculiar structure with the appearance of a head. This class for which the name of Worms is best retained, will contain the Helminths and Annelides exclusive however of the vermiform parasitic Crustacea, which embryology has taught us to refer unhesitatingly, to the class of Crustacea. The extraordinary diversity which exists among these animals renders it rather difficult to subdivide them into natural groups, and to assign to these groups a natural succession agreeing with the gradation of their structure, as there are so many the development of which is as yet very imperfectly known, and others which undergo so complicated metamorphoses as to leave great doubt respecting their natural relations to each other. However, there can be no doubt that Helminths rank lower than Annelides, for their structure indicates plainly their inferiority, and their mode of existence within other animals shows that they do not even reach that degree of independence which might allow them a free existence.

Among Annelides again there will arise similar difficulties respecting the relative position of the branchiate types of that group which are provided with external appendages performing simultaneously the functions of respiratory and locomotive organs, and those families which are deprived of external appendages, or which have stiff bristles upon their joints, independent of their aërial respiratory organs. Indeed at present the position of earth worms and leeches among Annelides, has not been the subject of any direct investigation as regards their relative position and rank. But if I were allowed to be guided by the impressions I have received from the study and comparison of the larvæ of insects, I should be inclined to consider the annelides with external gills as inferior to those which have no such appendages, and place the lumbricine Annelides highest in the class. So that Helminths should be placed lowest in the class of worms; next the Branchiate Annelides with external branchiæ; next those having internal branchiæ, and highest those with aërial respiratory sacks.

The second class in the type of Articulata is that of Crustacea, the natural circumscription of which can hardly be in any degree a matter of doubt, for these animals, with their distinct articulations, and aquatic mode of respiration, external appendages and particular mode of combination of the rings of their body, wherever they are combined to subdivide the body into distinct regions, are so peculiar as to determine well the natural limits of this class, to which we refer also the Cirripeda notwithstanding their transformations, also the Lernæan parasites, though they may assume

in their parasitic mode of existence so extravagant forms, and an appearance so entirely different from that of common crustacea. In this class, again, the parasitic vermiform types rank lowest; next follow the Entomostraca, and highest the Malacostraca, in most of which the anterior rings are combined into a distinct region, assuming a peculiar appearance differing widely from the posterior free movable rings. The circumstance that among Crustacea the organization reaches a point where the anterior part of the body assumes so peculiar an appearance, leaves no doubt as to the relative position of Crustacea among Articulata; they rank higher than worms; though they must be placed below the insects notwithstanding their perfect circulation and their otherwise highly developed structure; for, in every respect, insects considered as a whole class, are more highly organized, their higher types assuming a division of the body into three distinct regions; —undergoing also far more extensive metamorphosis, and assuming finally an aërial mode of respiration, to which the Crustacea do not reach. For these reasons, which I have illustrated more fully on another occasion, I have no hesitation in placing the class of insects highest among Articulata, and in comprising in one class the true insects with Arachnida and Myriopoda, which are only lower degrees of development of the more special types of true insects; the Myriopoda representing in a permanent state of development, and with the structure of true insects, the form of their caterpillars; the spiders with their cephalic and thoracic rings united into a cephalo-thorax representing their chrysalis in a permanent state of development; and the true insects with their three distinct regions, the so-called head, thorax and abdomen, ranking highest among them, as well for their more extensive metamorphosis as for the characteristic division of the body, the reduction of their locomotive appendages to a peculiar region, the complication of their chewing apparatus, and the development of their wings. The true arrangement of the different members of this class however is readily indicated by the remarks already made upon this class, and we shall not hesitate to consider Myriopoda as their lowest type, and to place Arachnida next above them, and then true Insects, among which the sucking tribes rank highest.

If we now consider the connection of these three classes with the elements in which they are developed, and in which they permanently live, we cannot fail to be struck with the fact that two of their classes are either parasites or entirely aquatic, for even the terrestrial worms live in moist ground or on the bark where moisture is constantly accumulating; and these two classes we have seen to be the lowest of the type, while the class of insects, which, in their perfect development, are all terrestrial or aërial, constitute the highest type.

Reviewing the secondary groups of all these classes also in the same connection, we find that the lowest of all not only live in a fluid medium, but require the existence of other animals in whose cavities they find shelter and means of subsistence; and among those which have an independent mode of life we find that the marine worms are probably lower than the fluviatile, and terrestrial,—at least, if the view expressed above respecting the relative position of Lumbrici and branchiate Annelides be correct.

In the class of Crustacea we have exclusively aquatic animals, and we find that among them those which live as parasites upon other animals rank lowest. The distinction however between fluviatile and marine types in this class does not seem to be in strict accordance with their gradation, for we have fluviatile Decapods which cannot be considered as higher than the crabs, unless it were shown that the shortened body of the Brachyural Decapods is the result of a retrograde metamorphosis, which I am however not inclined to suppose, as we have some crabs which are in the habit of leaving the water to dwell upon the main land. The occurrence of parasitic Crustacea upon fresh-water fishes, again, seems to indicate that here the parasitism prevails over the influence of the surrounding media; and we should not wonder at this circumstance, as a parasitic mode of development dependent upon the prior existence of organized beings, is not only a prominent feature in the mode of existence of so many Worms and Crustacea, but also even of many of the Insects, especially of the tribe of Arachnida and Diptera, at least in some earlier periods of their existence. In this connection it is an interesting fact to notice that the American fresh water Crustacea, the craw fishes, have fewer pairs of gills than the other representatives of the class.

Again, it may be, that to appreciate truly natural relations of this type of animals, it will be necessary to consider separately each of their minor divisions rather than the whole class as a unit; as we shall have to do also among the reptiles where the peculiarities of the primary divisions overrule the influence of the media in which they are developed.

However obscure these relations may be among Crustacea owing to the parasitism of some of their types, or the peculiar metamorphosis of others, if we now consider the insects proper we shall find here again a strict accordance with the results we have already derived from the investigation of the lower classes. Having acknowledged the superiority of the sucking insects over the chewing tribes, we cannot fail to perceive that Neuroptera, which must be considered as the lowest, inasmuch as their body still preserves the elongated form of worms, are aquatic in their larval condition and have even external gills, as their respiratory organs during that period. Next, Coleoptera among which also we find

aquatic larvæ, and a number of terrestrial types, and highest the Orthoptera which undergo a less extensive, but entirely terrestrial, development, whilst Hymenoptera have a more diversified metamorphosis, and assume even in their larval condition in some of their types, the higher forms which characterize the larves of Lepidoptera.

Among the sucking insects we begin again with various aquatic types, or aquatic larval forms,—next rise to Diptera with other aquatic larval conditions but a constant aërial mode of life in the perfect state, and finally to the type Lepidoptera in which all larvæ are terrestrial, and even highly organized in their earliest state in the higher groups; so that the class as a whole does not only rank above Crustacea for its structure, but consists chiefly of aërial types in their perfect state of development, a large number of which are aquatic but fluviatile in their larval condition, and comparatively exceedingly few marine. So that if we compare the whole type of Articulata, with either Mollusca or Radiata, we see that in accordance with the higher development of its structure it has not only proportionally a larger number of terrestrial and aërial types, but an entire class is throughout aërial in its perfect state of development, and, though aquatic in the stages of growth, these larvæ are chiefly fluviatile and not marine, so that we may conclude from zoological evidence that the more intimate connection with the main land and aërial mode of existence indicate a higher degree of development than an aquatic mode of life; and between the animals living in water, that fluviatile types must rank higher than the marine.

These views are fully sustained by the order of succession of these great types of the animal kingdom throughout the earlier geological periods; for as it is already ascertained from zoological comparisons, that the earlier types in each class rank lower than their present living representatives, we have further evidence from the circumstances under which they live that they were all aquatic and marine in the earliest periods, and that fluviatile and terrestrial types have followed only at later periods. Without alluding to those classes in which the gradation of fossil types is less distinctly shown, let me only recall the Crinoids among Echinoderms, which for so long time prevailed to the almost entire exclusion of all other families among Acephala; the great prevalence of Brachiopoda in the oldest deposits and the first appearance of Naiades in tertiary beds; the large number of branchiate Gasteropoda up to the time of the tertiary period, when Limnææ and Helices made their first appearance; the earlier development of Crustacea with more uniform joints, and the appearance of insects of the tribe of Scorpions anterior to that of the winged families, among which the Neuroptera seem to be the first to increase in number, and the late occurrence of the sucking

tribes in tertiary beds, and there will be no doubt left that the gradation of structure is intimately connected with the extension of continental lands, and that the present connection of animals with the surrounding media in which they live agrees also with their natural gradation. If we would study the natural relations between animals and the media in which they live, we could not begin with better prospect of success than by investigating minutely the different families of Vertebrata separately, rather than the whole classes of this great type. For though it is at once apparent that the class of Fishes as a whole is entirely aquatic, and stands at the same time lowest among Vertebrata, as soon as we pass to the investigation of the Reptiles we find aquatic and even marine types among Turtles, which rank much higher than the whole order of Batrachians, which are almost entirely fluviatile; and we find again marine and fluviatile types among Birds and Mammalia, the highest of all Vertebrata. These facts show most conclusively that an organization as high as that of the Vertebrata —introducing a mode of existence so independent of the changes of the seasons throughout the year, so durable as to last for numbers of years, (whilst among Invertebrata, and especially among Insects, but also among many other animals of lower type, there exists the most intimate connection between their development and the course of the seasons); we say these facts show that with such animals which are placed so far above the influence of physical conditions, their connection with the circumstances under which they live is much weaker, so much so that internal structure overrules greatly the foundation of those connections which are so intimate in lower animals, and reduces their limits to subordinate connections between members of the minor groups; while in the class of Fishes—the lowest—the whole type is organized in such a manner as to make it uniformly dependent upon one of the natural elements in which animals live, the three other classes present most diversified combinations, there being marine, fluviatile, and terrestrial or aërial types in these classes, under the development of as many structural types, differing almost in the same degree when contrasted with each other and so much that the aquatic Mammalia even in their marine types, or the marine Turtles, differ as much from each other or from Birds as they agree with their respective fresh water or terrestrial types. These discrepancies between the great types may be owing to other motives in the plan of creation than those to which they are here ascribed. The apparent anomalies between some of the articulated types may also be the results of combinations different from those with which they are connected above. But whether these views are correct or not, I have no doubt that the study of the phenomena which I am now contrasting, cannot fail to lead finally to a more correct appreciation of the natural relations

which exist between animals and the media in which they live, than the vague views which have prevailed lately from want of investigation of the subject rather than from an especial view taken of it; I am far from supposing that in every instance I have hit at the outset the true view. I shall be satisfied to have called forth direct investigation upon this question, and led the way in a field which promises so ample reward.

Before entering into a special investigation of the natural relations of Vertebrata and the surrounding media, it may not be out of place to call attention to some collateral facts which will appear particularly prominent in the type of Vertebrata, but which have already their value in the study of the lower types. I allude to the relative bulk of animals of the same type living in different media. We can derive no impression upon this point from the investigation of Radiata, as they are all aquatic, and almost entirely marine. But the difference is already marked between Mollusca if we contrast their marine and their fluviatile and terrestrial types within the limits of their natural secondary groups. Among Acephala, if we consider the Lamellibranchiata, we can not fail to observe that the marine representatives are as a whole and taking into consideration the proportional number of their genera and species, of larger size and greater weight than the fluviatile. We have nowhere such gigantic, bulky and heavy fresh water Bivalves, as are many of the marine shells, and we need only compare the large Chamas or Tridacnas and Hippopus, the gigantic Pinna, even with the largest of Anadonts; and again the numerous species of Cyclas, &c., with the smaller marine Bivalves, among which we find but few species of so minute types. Again, among Gasteropoda how much larger are most of the Univalve marine shells, such as Dolium, Strombus, Voluta, and others, than even the largest fresh water Ampullariæ and the whole lot of fresh water and terrestrial Pulmonata, among which latter we have absolutely the smallest of all Mollusca in the innumerable varieties of Pupa, and other genera. We reckon in this type of Gasteropoda, the minute species by hundreds, while there are exceedingly few of really small size among the marine ones, and the greater number are even universally above the medium size of the larger fluviatile and terrestrial types.

Among Articulata the same rule obtains, and here we may compare classes with classes, even in their different stages of growth. Are not the Worms, taken as a whole, larger animals than the Caterpillars? Do we not find among marine Worms by far the largest types? We need only remember the gigantic Eunice, or even the parasitic Tape Worms to be satisfied of the fact. Are not the Crustacea as a class composed of types exceeding far the largest of Insects even with their wings spread? Are not the marine Lobsters many times larger than the fresh water Craw

Fishes? A minute investigation of the details of this numerous class might lead to very interesting comparisons which however would be out of the way in this general sketch.

I shall mention only a few facts to show that these comparisons might even be traced between the different stages of growth of these animals. It must be, for instance, a matter of surprise to see that the body of so many Insects is smaller in their perfect state of development than as a pupa; and that again this is smaller than that of the larva, though the larva be after all only the younger state of the pupa, and the pupa the younger state of the perfect Insect. But in the same ratio as we find so frequently throughout the animal kingdom that the lower condition of structure and development of a type is manifested in a more bulky body, so we find among Insects, that their earlier state of metamorphosis which is developed under inferior circumstances, reaches its final growth in a more bulky body than that of following periods during which their successive moultings and the transformations of the substance of the body takes place; the greatest size which the larva acquires is first reduced in its transition into a chrysalis, and this again is reduced in its transition into a perfect Insect,—the development of wings only leaving them seemingly of greater size when their surface is extended, though the bulk as a whole be reduced. Weighing these animals in these different states of development will satisfy the most incredulous of the reality of what is here stated, should the appearance have deceived him before. A Silk Worm when it begins to spin is much heavier than the chrysalis, and this heavier than the perfect Moth. Without directly weighing these animals, we might be satisfied about this fact if we should consider the amount of silk which is thrown out by the latter, and the amount of fluid which is discharged by the Moth even before it rids itself of its load of eggs and sperm to enjoy the last moments of its complete maturity.

If we now allude to the Vertebrata we shall find very similar facts, and perhaps in the animals to be mentioned, inducements for the discovery of curious unnoticed connections. And here again we should be cautious for reasons alluded to already above, not to take the classes as such, but rather to consider their different types separately; for the class of Fishes as a whole cannot be said to contain the largest Vertebrates, nor even to afford any support to the view that aquatic animals in general are larger than terrestrial, for we find proportionably a much greater number of large species among Mammalia than among Fishes; we find a greater number of large terrestrial Reptiles than of aquatic ones. But if we review the classes separately, and consider their secondary groups by themselves, we find that the rule holds good, but bears, at the same time, most interesting reference to the order of

succession in geological times, as the respective types of any given group are the larger in the present period, whether terrestrial or aquatic, for being representatives of families which had numerous representatives in older periods. Among Fishes, we find the largest in the family of Sharks and Skates, Sturgeons and Garpikes, the first of which are exclusively marine, the second marine and fluviatile, the third entirely fluviatile; but the three types are either exclusively representatives of families largely developed in former geological periods, or so connected with extinct types as to show that this connection has influenced their development.

Among Reptiles we find the largest in the family of Turtles among their marine representatives; among the Lizard-like, in the fluviatile Crocodiles; among Batrachians, in their aquatic families.

In Birds, the aquatic families, Pelicans, Geese, Ducks, &c., bear a much larger proportion of heavy bulky forms than any terrestrial families; and if the Ostrich should at once occur as a striking exception, let us not forget that the giants of this family are known in a fossil state, exceeding far their living representatives.

Among Mammalia, we have the Whales as the largest class, and if we should be reminded of the great size of terrestrial Pachyderms, let us not forget that Pachyderms were the prominent type of Mammalia during the tertiary period. In connection with these facts it might be shown that natural families throughout the animal kingdom, are constructed within limits of size, which do not admit of great differences. A comparison of Cetaceans with Rodents, of Ruminants with Bats, of Passerine with Gallinaceous Birds, of Sharks with Herrings, of Cod-fishes with Blennoids, of Cuttle-fishes with Pteropods, of Crabs with Entomostraca, &c., might easily satisfy the most skeptical, that there are natural limits assigned to certain combinations of structure and the material bulk of the animals in which they are manifested.

After this digression let us return to our consideration of the natural connection of the secondary groups of Vertebrata, with the elements in which they live.

Though the class of Fishes is entirely aquatic, we have among these animals a greater number of marine types, and some which are partly marine and partly fluviatile, or, at periods, marine, or, at periods, fluviatile; and others which are entirely fluviatile or almost so. And though, at present, it is not plain that fluviatile types on the whole are superior to the marine types, we should not lose sight of the circumstance that the only living Sauroids, which have so many characters by which they may be connected with the class of Reptiles, and considered as the highest among Fishes, are entirely fluviatile; both Lepidosteus and Palypterus occur only in fresh waters; some of the Lepidostei only are

known to reach the mouths of rivers emptying into the sea. And though the families of Sharks and Skates are chiefly marine, numbers of them, especially of those types of Skates which have numerous fossil representatives during the tertiary period, such as Myliobatis, are known to ascend freely the rivers in tropical regions. Among Cyclostomes, the lowest type Branchiostoma is marine, Petrostoma proper being both marine and fluviatile, the higher type of Ammocœtes (for we must consider Ammocœtes as higher, inasmuch as the division of the lips indicates a tendency towards a formation of a distinct upper and lower jaw), is exclusively fluviatile. The Goniodonts which from their affinities to Sturgeons rank higher than the Siluridæ, are exclusively fluviatile, whilst there are some marine types among the latter. Among Percoids we find in fresh water a larger number of those in which the two dorsals are distinct, a character making them eminently superior to the forms with undivided fins. For the same reason we should consider the Sparoids inferior to the Percoids, their dorsals being not only generally undivided, but even covered with scales. Among the Eels, those destitute of all fins are exclusively marine, those without pectorals also exclusively marine, and we may fairly consider the fresh water Eels as the higher type of the family on this ground. If there is any natural connection, as I have attempted elsewhere to show that there is, between Scombroids and Scomberesoces, and Esoces proper, it becomes plain at once that the latter are the higher from the abdominal position of their ventrals, and they are a fluviatile family. Even taking the Cycloids as a whole, we find among them the lower families of Thoracici and Jugulares, as the families of Cod and Scombrides, chiefly marine, whilst the family of Salmonidæ, and Cyprinidæ are chiefly fluviatile. Among the Gadoids we have those with many vertical fins, as the true Cod, marine, while those in which the dorsals and anals are reduced such as the genus Lota are fluviatile. Even among the Salmonidæ in the widest extension which this family had formerly, we find the Scopelidæ with the inferior structure of their jaws chiefly marine, while the Coracini and true Salmonidæ are chiefly fluviatile. Everywhere, in fact, in each minor group, the fluviatile representatives show characters indicating their superiority over their marine representatives. Whatever exceptions might be found to this law, which in the outset appears so general, I have no doubt will lead at some future time to the discovery of some other principle as yet unknown.

The class of Reptiles is one of the most interesting in the point of view under consideration, and each of their types exemplifies in itself the law of the intimate connection between animal types and the media in which they live in the most striking manner, inasmuch as here the gradation, which might be inferred from

structural and embryological evidence, agrees most fully with the gradation of the elements in which they live. Among Batrachians we have chiefly fluviatile and terrestrial families. The Ichthyodes, or Batrachians with permanent branchiæ, are all aquatic, and acknowledged the lowest in the class. Some of their lowest representatives occur even in brackish swamps, and, as soon as attention is called to this subject, it cannot fail to be perceived that the Frogs with their more or less palmate fingers, and their more aquatic habits, rank lower than the Toads with their divided fingers and terrestrial mode of life. Among Ophidians we have chiefly terrestrial families, and only a few marine and aquatic ones; but who can fail to perceive that the marine serpents with their flattened tail, are inferior to the terrestrial genera, and that among these it is a well known fact there are some with rudimentary posterior extremities which assigns them a superior rank. Some objections might be drawn from the consideration of the Saurians, among which, the highest type, the Crocodiles, are chiefly fluviatile; but it has elsewhere been shown that Crocodiles are not truly Saurians of the same type with our Lizards, but modern representatives of a large family which was very numerous in former geological periods, when their first representatives were marine types provided with fins instead of distinct fingers; so that, far from being an exception, the Crocodiles of our days which are either fluviatile or terrestrial, must be considered as the highest representatives of that almost extinct type of Reptiles, the earliest forms of which were marine, followed by fresh water. Finally, among Chelonians the gradation in connection with the natural elements in which they live is most striking, for the inferiority of marine Turtles is as plain as it can be, not only in the form of their organs of locomotion, but even in the peculiarity of many of their internal organs especially of their ovaries, which contain eggs almost as numerous as those of Fishes. Next we place the fresh water Turtles with palmate fingers, and highest, terrestrial Testudines with their short undivided fingers. So that we have in this class with its various marine and fresh water and terrestrial types, not only a full illustration of these laws, but so intimate a connection between gradation of structure and mode of living in various elements, as to lead to the conviction that the mere mode of living might in many instances be almost as safe a guide to ascertain the natural gradation of types, as the study of their internal structure.

Ever since the class of Birds has been the object of regular investigation, their aquatic types have been considered as inferior to the terrestrial ones, and among the former, those which live entirely an aquatic life are decidedly the lowest. They are so, not only on account of the more imperfect development of their legs, which preserve throughout their embryonic form, but also

in the less extensive development of their wings, in the more scale-like form of their feathers, and the greater number of eggs they lay, and the less care they take of their young, which are hatched in a state of development in which they are already prepared to provide for their own food. The same is the case with the Gallinaceous and the Wading Birds, which, though more advanced in many respects, are still inferior to the climbing and Passerine Birds in this respect, having a heavier flight, if they fly at all, and living a more terrestrial, and even aquatic life; the Wading Birds coming nearer in this respect, to those with palmate fingers, and the Gallinaceous Birds, as well as the Ostriches having a more terrestrial mode of life, whilst the Passerine Birds rank higher in all these respects, feed their young, and take care of them for a longer time, and live almost exclusively an aërial life, few of them having aquatic habits, and those being in their respective families by their form as well as by their mode of life, decidedly inferior to their loftier relations.

The classification of Birds as a whole is still so imperfect, though their minor groups are well understood, that many important relations in these respects must necessarily be more or less concealed as long as their primary divisions are not better known; so that we may expect many interesting hints from further investigations in this view.

The class of Mammalia is not only the most diversified in the forms of its members, but also in the diversity of their mode of life; nevertheless this diversity is connected by the most intimate relations of structure. The Whales are as much Mammalian by their internal organization as the most exclusively terrestrial quadrupeds. True Cetaceans constitute a natural family, all the members of which are exclusively marine, and no one of them even fluviatile—for the Sirenidæ must be considered as entirely distinct from true Cetaceans; and these Cetaceans, at the same time that they are so exclusively marine, are also the lowest type of Mammalia, not only from the imperfection of their extremities, of which there is only one anterior pair, and from the want of hind-legs, but also from the extraordinary development and bulk of their muscular tail, and the development of a caudal fin, and sometimes even a fin-like fold of the skin upon the back. If it can be shown that the Sirenidæ are an aquatic type of a larger group embracing Pachyderms, the direct relation of their structure and mode of life will be at once obvious, since Sirenidæ are either marine or fluviatile, while true Pachyderms are terrestrial; and should we not be justified in considering the subaquatic Hippopotamus as inferior to its more terrestrial relatives of the genera Rhinoceros, Elephant, and Horse? Are we not to consider the Ornithorhynchus, with its palmate hind-legs and spur, as inferior to Echidna? Are not the palmate Rodentia inferior to the ter-

restrial and arboreal types? Are not the aquatic Shrews inferior to the arboreal Insectivora? All these secondary questions will receive, in future, due attention and will no doubt be satisfactorily settled. But there are families in which we can already see our way and arrive at precise conclusions. Among Carnivorous Mammalia we have three very distinct types, the Pinnipoda or Seals; the Plantigrada or Bears, and the Digitigrada, Dogs and Cats. Now even if objections were raised against the association of the Walrus with the common Seals, there can be no doubt of the inferiority of the latter when contrasted with Plantigrada and Digitigrada. Their short fin-like legs, their clumsy body in connection with their aquatic marine life, assign them a lower position, and the Plantigrada must be considered as intermediate between them and the Digitigrada. Now among Digitigrades, even if we take isolated genera, we are led to assign to the species with aquatic habits, an inferior position among their nearest relatives. The polar Bear comes decidedly nearer the Seals in all its habits, than any other species of that genus, and on that ground should be considered as inferior to the terrestrial species. Again, the others, with their palmate fingers, rank lower than their terrestrial relatives: and we may even find that such considerations will hold good among the varieties of one and the same species; for we have varieties among the Digitigrade Dogs in which the fingers are palmate, a character which is derived from the imperfect development of their legs, preserving throughout life their embryonic form; and these varieties among Dogs are the most playful and at the same time, most aquatic in their habits, preserving in their adult state characters of the young and habits of the lower types,—this playful disposition being universal even among the most ferocious of the Cat tribe. I shall abstain purposely from tracing these comparisons higher up among Monkeys, and in the human families, from fear of alluding to exciting topics; but leave it to the philosophic observer to consider how far the idea of an aquatic Monkey is compatible with the high position which these animals hold in the class of Mammalia; and how curious it is that in the human family there are races which differ so much in their natural dispositions, mode of life, habits and adaptation to higher civilization; and how closely these natural dispositions are connected with apparently insignificant peculiarities of structure.

Upon reviewing the facts mentioned above, and the inferences derived from the facts, no impartial observer can in future deny the importance of the study of the natural relations between animals and the media in which they live; and the close connection which exists between them and the gradation of their structure. But this being the case, it must be a matter of surprise that the views so long entertained of the importance of this connection,

which led earlier naturalists, generally, to the classification of animals according to the media in which they live, should have been so completely abandoned, and even considered of no value at all in systematic classification. For my own part I have no doubt that this negative result has arisen from the circumstance that all aquatic animals were brought together, in these earlier attempts, without reference to their structure or organic development, while we have found that structure is the ruling principle, and that natural connection with the element, is the secondary motive by which these connections are influenced. Indeed, aquatic animals, though agreeing in many respects, and though provided with analogous apparatus to perform the same functions, have, in different types of the animal kingdom, a very different plan of structure, and very different organs to perform the same functions. I shall not enter into a detailed illustration of these differences, as I have alluded to these facts in other papers, but only recall here, the great difference which exists in these connections between the different types.

Among Radiata, which are all aquatic, we find even that the adaptation to the liquid element is introduced in a plan of structure which is widely different from the plan of structure prevailing in Mollusca, though they also are chiefly aquatic; and that even the terrestrial types of Mollusca present, for adaptation to an aërial mode of life, only a modification of their aquatic types. The same may be said of Insects, in which the structure is mainly that of the Crustacea and Worms, which are permanently aquatic types, presenting simply a transformation of those peculiarities of structure which enable the lower classes to live under water, such as will enable them to rise in their adult state into an aërial condition of existence. Among Vertebrata the case is very different. The type is constructed for a terrestrial and aërial mode of life; even their aquatic representatives have rudiments of the apparatus, which acquire the highest development in the complete terrestrial types, and most of their aquatic types are truly aërial animals living in water, just as Insects are aquatic types adapted to the air. Let us only contrast in this respect, Cetacea with common Articulata. They have a pulmonary mode of life as much as man; they have the same mode of reproduction; only their form enables them to dive under water and to dwell permanently in the Sea; but, for all their structure, they are truly aërial animals. And this is equally the case with Birds and Reptiles; and with the Fishes I am prepared to show that there is no difference in this respect. For, though in their perfect state, Fishes are exclusively aquatic, they are completely built upon the same plan with those aërial classes of Vertebrata. The difference here is only this that the branchial apparatus, which exists simultaneously in Reptiles, Birds, and Mammalia, in their imperfect condi-

tion, is developed to be a permanent organ of respiration, while it is reduced and disappears in the higher classes in proportion as the lungs acquire a greater development. In Fishes, on the contrary, the homologue of the lung remains functionally and organically in a rudimentary state, as an air bladder. But all classes have both apparatuses in an inverse state of development, and thus Fishes are as fully constructed on the plan of the higher Vertebrata as the aërial Invertebrata are on the plan of their aquatic types. But the circumstances that Fishes have the double type of respiratory organs, and that the pulmonary one which by no means exists in any Invertebrates as I have shown elsewhere, but throughout the Vertebrata including Fishes, show that the whole type of the Fishes, have to be viewed in the same light as Reptiles, Birds and Mammalia, and must therefore be only considered as a lower condition of these aërial types, and not the latter as a higher degree of the former. For tracheæ of Insects, and lungs of Spiders, are only modified branchiæ of the type of Articulata, just as much as lungs of Pulmonata are modified branchiæ of the type of Mollusca, while gills and lungs in Vertebrata are parallel systems both coëxisting in all of them and only acquiring respectively a different degree of development in each of their classes. These facts which I have traced in other papers through a special comparison of all the homologies of the different types of respiratory organs in Vertebrata, Articulata, Mollusca, and Radiata, show plainly, that the aquatic, marine, or fluviatile, and terrestrial mode of life are introduced throughout the animal kingdom by special adaptations of peculiar different systems of organs performing analogous functions; and that the failure of introducing the consideration of the adaptation of animals to the media in which they live, in the plan of their classification, must be ascribed to the fact that these analogous structures were in the beginning considered as identical features in the organization. But taking in future into consideration all these peculiarities, we shall rapidly proceed towards the full understanding of all the relations between the gradation of animals, and the media in which they live, as far as they are not yet fully understood.

An extensive review of the Vertebrata might long ago have led to such conclusions, but before they could be considered as a general law ruling the whole animal kingdom, it was necessary that they should be treated in a special manner through the innumerable types of Invertebrated animals; and we have seen that this agreement is as close and as complete throughout the types of Radiata, Mollusca and Articulata, as it is plain among Vertebrata, and the slight difficulties to which we have alluded, must probably be referred to the present state of our knowledge respecting some of them, rather than to a departure from this law in any of their types.

Art. XXXVIII.—*On a new Analogy in the Periods of Rotation of the Primary Planets, discovered by Daniel Kirkwood*, of Pottsville, Pennsylvania.

(From the Proceedings of the American Association for the Advancement of Science, 2nd meeting, held at Cambridge, 1849. p. 207.)

Mr. Sears C. Walker addressed the Association on the subject of a new analogy in the periods of rotation of the primary planets, discovered by Daniel Kirkwood, Esq., of Pottsville, Pennsylvania.

The subject of my present communication is contained in a letter of Mr. Daniel Kirkwood, of Pottsville, Pennsylvania, dated July 4th, of this year.

The Secretary then read Mr. Kirkwood's letter, as follows:—

Pottsville, Pa., July 4th, 1849.

Sears C. Walker, Esq.,

Dear Sir,—Knowing the great interest you feel in astronomical inquiries, I take the liberty of submitting the following paper to your consideration, and respectfully soliciting your opinion as to the problem which I have been attempting to solve. Is it, or is it not, deserving of further investigation? Whatever may be your decision, as I have the fullest confidence in your judgment, I shall at once aquiesce. Wishing to be as brief as possible, I will not trouble you at present with any statement of the considerations which suggested my hypothesis.

While we have, in the law of Kepler, a bond of mutual relationship between the planets, as regards their revolutions round the sun, it is remarkable that no law regulating their rotations on their axes has ever been discovered. For several years, I have had little doubt of the existence of such a law in nature, and have been engaged, as circumstances would permit, in attempting its development. I have arrived at results, which, if they do not justify me in announcing the solution of this important and interesting problem, must at least be regarded as astonishing coincidences.

Let P be the point of equal attraction between any planet and the one next interior, the two being in conjunction: P′, that between the same and the one next exterior.

Let also D = the sum of the distances of the points P, P′, from the orbit of the planet; which I shall call the diameter of the sphere of the planet's attraction;

D′ = the diameter of any other planet's sphere of attraction found in like manner;

n = the number of sidereal rotations performed by the former during one sidereal revolution round the sun;

n'=the number performed by the latter; then it will be found that $n^2 : n'^2 :: D^3 : D'^3$; or $n = n' \left(\frac{D}{D'}\right)^{\frac{3}{2}}$.

For the sake of convenient reference, I subjoin the following tables. The masses of Venus, the Earth, Mars, Jupiter, and Saturn, are taken from your edition (1845) of Sir John Herschel's Treatise on Astronomy. Those of Mercury and Uranus correspond with my hypothesis, and are nearly identical with the most recent and reliable determinations of astronomers. In other words, the mass of Mercury is very nearly a medium between the two estimates of Encke,* while that of Uranus is more than $\frac{1}{1}\frac{7}{1}$ths of Struve's mass, $\frac{1}{2}\frac{1}{2}\frac{1}{0}\frac{1}{0}$ found by observations on the satellites.† The mean distances not being given in miles in Herschel's Treatise, I have used the table of distances in the Astronomy of Professor Norton. For Mars's period of rotation ($24^h\ 37^m\ 20^s.\ 6.$) I have adopted the recent determination of Prof. O. M. Mitchel, (*Sid. Mess.*, vol. i, p. 52).

TABLE I.

Planet's name.	Mean Distance from the Sun in miles.	Mass.	Square root of Mass.	No. rotations in one Sid. Period.	Log.
Mercury,	36,814,000	277,000	526·3	87·63	1·942653
Venus,	68,787,000	2,463,836	1569·6	230·9	2·363424
Earth,	95,103,000	2,817,409	1678·5	366·25	2·563777
Mars,	144,908,000	392,735	626·7	669·6	2·825815
Jupiter,	494,797,000	953,570,222	30879·8	10471·	4·019988
Saturn,	907,162,000	284,738,000	16874·1	24620·	4·391288
Uranus,	1,824,290,000	35,186,000	5931·5		

The points of equal attraction between the planets severally (when in conjunction) are situated as follows:—

TABLE II.

		Miles from the former.	Miles from the latter.
Between	Mercury and Venus,	8,029,600	23,943,400
"	Venus and Earth,	12,716,600	13,599,400
"	Earth and Mars,	36,264,600	13,540,400
"	Jupiter and Saturn,	266,655,000	145,710,000
"	Saturn and Uranus,	678,590,000	238,538,000

It will be seen from above, that the diameter of the earth's sphere of attraction is 49,864,000 miles. Hence the diameters of the respective spheres of attraction of the other planets, according to my empirical law, will be found to be as follows:—

* See Prof. Encke's letter to Mr. Airy, dated Dec. 20, 1841.
‡ Edinburgh Phil. Journal, for July, 1848.

	Diam. of Sphere of Attr.	Log.
Mercury, ...	19,238,000	1·283704
Venus, ...	36,660,000	1·564218
Mars, ...	74,560,000	1·872479
Jupiter, ...	466,200,000	2·668594
Saturn, ...	824,300,000	2·916127

Remarks.—The volumes of the sphere of attraction of Venus, Mars, and Saturn, in this table, correspond with those obtained from Table II; that of Mars extending sixty-one million miles beyond his orbit, or to the distance of two hundred and six million miles from the sun. This is about two or three million miles less than the mean distance of Flora, the nearest discovered asteroid. That of Mercury extends about eleven million miles within the orbit; consequently, if there be an undiscovered planet interior to Mercury, its distance from the sun, according to my hypothesis, must be less than twenty-six million miles. Jupiter's sphere of attraction extends only about two hundred million miles within its orbit, leaving eighty-nine million miles for the asteroids. It is only in the most distant portion of this space, where small bodies would be less likely to be detected, that none have yet been discovered.*

The foregoing is submitted to your inspection with much diffidence. An author, you know, can hardly be expected to form a proper estimate of his own performance. When it is considered, however, that my formula involves the distances, masses, annual revolutions, and axial rotations, of all the primary planets in the system, I must confess, I find it difficult to resist the conclusion that the law is founded in nature.

Very respectfully, your obedient servant,

DANIEL KIRKWOOD.

[The reading of Mr. Kirkwood's letter was followed by remarks by Mr. Walker who pronounced the analogy the most important which has been brought forward since the time of Kepler. Mr. Walker also read a paper prepared at the instance of Mr. Kirkwood, containing a mathematical examination of the law, in its application to the whole Solar System, using the most recent values for the elements of the planets. Another paper on the same subject was read by Prof. B. A. Gould. These we defer to our next number.]

We annex the following Letter, dated Pottsville, January 23, 1850, from Mr. Kirkwood containing a brief history of his very important discovery.—EDS.

---

* It may be proper to remark that *one planet* between Mars and Jupiter, with a mass and mean distance of about double those of the former, would perfectly satisfy the conditions of my theory.

The following is a very brief history of the astronomical discovery communicated to the American Association for the Advancement of Science, at its session in Cambridge, Mass., in August, 1849, by Sears C. Walker, Esq.

My first notions in regard to the existence of an unknown law regulating the revolutions of the planets on their axes, date some time previous to the commencement of 1839. No investigation of the subject, however, was undertaken until the spring or summer of that year, when, in reading Young's Mechanics, I was struck by the remarks at the 204th page in support of the conjecture that both the progressive and rotary motions of the heavenly bodies were originally communicated by the same impulse. While reflecting upon the subject it occurred to my mind that an examination of this theory, in case it were founded in truth, might possibly develop that harmony, of which I had for some time entertained a vague conception. Having determined to give the subject my earnest attention, I commenced by calculating the distance from the centre of each planet to the point at which, according to the known laws of dynamics, the projectile force must have been impressed.* These distances I compared with each other in a great variety of ways. Failing thus, however, to detect any relationship between the different members of the system, I abandoned this hypothesis as hopeless.

After this, my leisure hours were spent for several years, with no better success, in comparing the masses, volumes, densities, distances, &c. At length, as the only remaining source of hope, I took up the nebular hypothesis of Laplace. This was in 1846. Here I soon found that a proper discussion of the questions which presented themselves required an analysis beyond my reach, and that consequently there was little prospect of attaining my object by any direct process of mathematical reasoning. Still, however, I could not persuade myself utterly to abandon my laborious though hitherto unavailing pursuit.

I had not been long engaged in my researches on the nebular hypothesis when the diameter of the sphere of attraction presented itself to my mind as a probable element of the law sought. Further consideration of the subject led to the conjecture that the ratio of the angular velocity of translation to that of rotation, or, which is the same thing, the number of a planet's days in its year, might be another element. Finally, on the 12th of August, 1848, I obtained the simple analogy announced a few months since in my letter to Mr. S. C. Walker. My delight as I applied it to the different planets in succession and found its wonderful agreement with the known elements of the system, may well be imagined.

* In these calculations I was, of course, under the necessity of making certain assumptions in regard to the variation of density from centre to surface.

Some time previous to the date of my discovery, I learned that the nebular hypothesis had been abandoned by some of its most distinguished advocates in consequence of the revelations of Lord Rosse's telescope. This fact, together with several other considerations, prevented me from at once making the result of my investigations public. Having, however, again and again revised my calculations, and having found that according to the theory of probabilities there are many millions of chances to one against the accidental coincidence of so many independent variable quantities, I ventured to submit the subject to the inspection of astronomers. The interest it appears to have excited, and the favor with which it has been received, have exceeded my most enthusiastic anticipations. If it be indeed the expression of a physical law and not a mere harmony, it undoubtedly opens to men of science a vast field for cultivation.

ART. XXXIX.—*On the so-called Biogen Liquid;* by CHARLES GIRARD, Member of the Boston Natural History Society.

THE following pages are devoted to an examination of a letter published in the *American Journal of Science and Arts*,* also of a communication read before the *Boston Natural History Society* in December, 1848.†

The letter consisted of an exposé of three facts and one theory, viz.:

First fact. The formation of the egg in the ovary, as observed in a soft-shelled mollusk (*Ascidia*) and in a worm (*Sigalion*).

Second fact. The germinative vesicle does not always and necessarily disappear before the division of the yolk.

Third fact. There exists in the centre of the germinative spot, a transparent vesicle.

Theory. What embryologists have called albumen in the egg of invertebrated animals, has nothing in common with the albumen of the egg of Vertebrata. This liquid is the *mother liquid* of the yolk, that is to say, of the elements from which a new individual originates; therefore it is called *Biogen.*

These facts which have been added to science were not first made known by Mr. Desor. The theory is really his own. We shall presently see on what it rests.

In the communication read before the Boston Natural History Society, besides a brief account of the letter just mentioned, we find introduced some comparisons between certain pretended phenomena which are said to take place in the earlier age of the egg and the merely conjectural phenomena of the nebular hypothesis.

---

* Second Series, vol. vi, No. 21, (May, 1849,) p. 395.

† See Journal of that Society, vol. iii, p. 85.

Without further prefatory remarks, I proceed directly to take up one by one the facts, the theory, and the speculations.

I. The primitive egg has been made the subject of much research by Prof. Agassiz, especially in the department of Mollusca. Ascending even beyond the first existence of the egg, he has shown us the ovary itself in the process of development. This is composed of sacks or pouches varying in form and size, in which the eggs are formed. The sacks are filled with an homogeneous and transparent liquid. Soon this liquid becomes granular, that is, consists of cells, and the cells becoming more and more numerous, give birth to a little opaque sphere, which is the vitellus. The germinative vesicle and the germinative spot have appeared during the formation of the yolk, and sometimes even prior to this period; but at the moment when the phase of division commences, both the spot and the vesicle generally disappear, and in the interior of each of the spheres produced by the division, is seen a clear space.

A Résumé of these observations has been published.* Since then, Mr. Desor has observed analogous phases in other animals. He published them, as he had a right to do, but he should have at least declared at the outset, that he was doing nothing more than repeating the observations which another had made before him.

II. When an egg has reached that point of its history which is called its maturity, it is distinguished by the following characters:—a spherical mass, more or less opaque, which is the yolk; in the center of this is found a much smaller sphere, the germinative vesicle, containing another substance, usually transparent; then in the interior of this last, a sphere or spheres still smaller, the germinative spot or spots.

The epoch of the appearance of the germinative spot varies as it would seem within very considerable limits. This is not the place to discuss this question. Let it be observed, however, that they exist in every egg when it is mature, and that they disappear from every egg when it enters upon the period of division.

But among the Nemertes a curious phenomenon is observed. Generally as we have just said, the vesicle and spot disappear before the division of the yolk, or, at least, at the moment when it divides in halves. The secondary spheres resulting from the subdivisions of the vitelline mass, have then, each one in its interior, a clear space. The question has been raised, what part the germinative vesicle plays in the history of the eggs? Is the division the consequence of its disappearance? in other words, is its content necessary to effect the division. The germinative vesicle has been considered as containing the primitive elements of the

* Lectures on Comparative Embryology, by Louis Agassiz. Boston. January, 1849.

new being, or an element indispensable to its formation. Now here, among the Nemertes we meet with a case where the yolk is already divided into four parts, while the germinative vesicle still exists. The division of the yolk, then, can take place without the previous bursting of the germinative vesicle.

This fact is set forth and illustrated fully in the Lectures on Comprehensive Embryology,* and what appears strange to us, is, that Mr. D. now takes for his own, an observation to which he strongly objected when it was first communicated to him. Having made his observations upon a species different from that in which the fact was originally observed, there was, it seems to me, sufficient merit in pointing it out in another species, without claiming for himself the absolute priority.

III. In 1840, Mr. Martin Barry and Prof. Valentin, simultaneously observed, the one in England in the egg of the Rabbit; the other upon the shores of the Mediterranean, in the egg of a sea Urchin, (*Echinus lividus*,) that the germinative spot is not so simple as had been previously supposed. The observations of Mr. Barry were published during the same year;† those of Prof. Valentin, written in 1840, did not appear till 1842, and at this time he was still unacquainted with those of the English micrographer, for he would not have failed to mention observations so curious and a coincidence so remarkable. Prof. Valentin merely says that a round opaque body is often discerned in the center of the germinative spot.‡ In 1841, Van Beneden§ observed a granule in the germinative spot of the *Hydractinia rosea*, and in 1844,‖ when reconsidering the same species, he detected an opaque corpuscle within the germinative spot. This fact I have verified in 1848, in the case of the common sea Urchin (or sea egg) of Massachusetts Bay.

More recently Mr. D. says, that he has observed in a worm (*Sigalion*), and a sea anemone (*Actinia*), that the germinative spot contains a clear transparent vesicle. Comparing then this clear vesicle with the opaque nucleus observed by Prof. Valentin, he calls it *Vesicula Valentini*.

We honor the homage rendered to Prof. Valentin:—but Mr. D. has failed to explain how it happens that a transparent vesicle in the worms and sea anemone, is the same thing with the opaque nucleus of the sea Urchins; and moreover he ought not to have overlooked two points of its history, those which belong to Mr.

---

* Pages 70, 71. † Researches in Embryology: Third Series.
‡ Anatomie du genre Echinus, p. 105, Pl. viii, fig. 167.
§ Bulletin de l'Académie de Bruxelles.
‖ Recherches sur l'embryogénie des Tubulaires.—Mém. Acad. Brux., vol. xvii, p. 62, Pl. vi, fig. 6.

Barry and Van Beneden. By examining more closely, and studying more intimately the contents of the germinative vesicle and of the germinative spot, he might have satisfied himself that the presence of a clear vesicle, or of an opaque nucleus, indicates only two states of one and the same phenomenon, since they are observed alternately in the same species. This is the case with the eggs of Ascidiæ, of Medusæ, of Echini, and probably the eggs of many others.

By merely reading the paper of Mr. Barry, he might have been convinced that this observer had seen much deeper than any of his predecessors. Mr. Barry has pointed out a cellular content in the germinative vesicle, a thing then new to science; he believes this substance to be produced by changes which take place in the germinative spot. I do not enter into more full details upon the researches of Mr. Barry, for in that case I should be obliged to make some objections of secondary importance, which is not here my object. I had only to point out a fact, to correct an oversight. I now return to my subject.

IV. The researches of Mr. D. upon the development of the eggs of Ascidiæ, have led him to imagine a theory. This theory rests upon a false fact. According to this theory, the primitive state of the egg is a little sphere containing a transparent homogeneous liquid, in the midst of which sphere, may be already seen the outline of the germinative vesicle and spot. By degrees this liquid becomes *turbid*, and the germinative vesicle appears surrounded *by a slight cloud* which increases in extent until it fills the sphere of the egg. Then finally there is a retreat of the matter from the circumference towards the centre of the egg where it is condensed and forms the yolk. A free space remains between this last and the external membrane. This space is filled by a liquid; this liquid is the Biogen.

Having examined during many weeks and continuously each day the eggs of the same Ascidia which was the subject of his observation, I have never witnessed this phenomenon. And yet I examined them in individuals of very different sizes, and in most diverse conditions, taking care always that the egg should remain in its natural state; never, I repeat it, did I see this phenomenon of gradual condensation and of the retreat of the vitellus. Having tried all the good methods of which we can avail ourselves in the use of the microscope, the idea occurred to me to compress strongly a fragment of ovary. What was my surprise, at seeing living copies of the figures published upon this subject. It could even have been easy to make a more complete series of them. The eggs were no longer in their natural state; they were pressed down or crushed, their natural state destroyed, and this was the foundation upon which was built the theory

of Biogen liquid, which was to apply to the whole animal kingdom.*

What then is the liquid, and what part does it play in the history of the egg? This liquid is albumen, the albumen which is formed in the ovary, and to judge rightly of the part which it takes in the formation of the egg, some general considerations upon the primitive state of eggs are here necessary.

Prof. Agassiz† has already reminded us that the point of departure of the egg is the same as that of the cells of the organic tissues. There is a period when the ovule is only a minute cell. More recent observations confirm these first results. To know the origin of the egg, we must then ascend to the origin of cells.

There are *primordial cells*, and *derived cells*. The experiments of Dr. Ascherson,‡ have taught us that primordial cells are formed of two substances; of an oily substance and of albumen. Cells perfectly like primordial organic cells can be made artificially by bringing an oily liquid into contact with albumen, although the albumen and the oil or oily matter show a perfect continuity of substance when we examine them separately. But bring them in contact, and cells are formed immediately. Every physiologist can repeat these experiments, and ought to do it.

Primordial cells once formed in the manner above indicated, another phenomenon presents itself. They become nucleated, and these nuclei enlarging, give birth to derived cells.

Thus derived cells are multiplied by the growth of the nuclei, according to the researches of Mr. Martin Barry,§ of Prof. Agassiz and my own, and whenever the third generation appears, the parent cell bursts and allows its contents to escape; it is in this way that they increase in number.

Now the only difference there is between the cells of the tissues and eggs, is that in these last the parent cell never bursts,‖ the primordial cell preserves within itself all the subsequent generations of derived cells; which by their accumulation, form the substance out of which the new individual is produced.

Applying now this knowledge in a more special manner to the development of eggs, we can reply to the question asked above, viz., what part does the albumen play?

---

* If the Biogen is so general, I would ask why it was not shown in the Sigalion and the Sabella of which Mr. Desor also speaks?

† Lectures on Comparative Embryology, 1849, p. 81.

‡ Ueber den physiologischen Nützen der Fettstoffe und über eine neue auf deren mitwirkung begründete und durch mehrere neue Thatsachen unterstützte Theorie der Zellenbildung.—In Müller's Archiv. fur Anatomie Physiologie, &c. 1840, p. 44. —Comptes Rendus de l'Institut, vol. vii, 1838, p. 837. (*Sur l'usage physiologique des corps gras.*)

§ Researches in Embryology: Third Series.

‖ I mean, at least, as long as the new individual is not ready to escape out of the egg.

At a determinate epoch, for each species, the ovarian sacks are filled with primordial cells. It would be premature to raise the question whether they are formed in the ovary itself, or are brought there already formed. Let us take them, as they exist in the ovary. There under the influence of the organism, they pass through that course of development which we have pointed out as proper to cells destined to become eggs. They contain at first oil. By endosmosis albumen passes through the envelop or membrane, and coming in contact with the oil, cells are formed, the constituent cells of the vitellus (the granules of the yolk). When the oil is exhausted, no more cells are formed. The mass of the vitellus then increases, after the ordinary method of multiplication by the growth of nuclei. The albumen itself continues to penetrate through the membrane of the cell, which has now become an egg. It remains under the form of albumen, and surrounds the vitelline globe with a concentric zone more or less thick which increases as the egg grows larger. The intermediate space between the yolk and the external envelop (*chorion*) being increased, one would be tempted to acknowledge a withdrawing of the vitellus from the circumference towards the centre, if it were not known that all parts of the egg enlarge in the same proportions. Besides, a yolk which retreats, which is condensed, ought to occupy a less space, while the contrary is the fact, even as shown by the drawings made by Mr. Desor himself.

The conclusion is doubtless, already anticipated, that the pretended biogen liquid is found to be nothing more than an accumulation of albumen, the albumen formed in the ovary. An embryologist would have known that the yolk of the egg of all animals is composed of albumen and of an oily substance, and that no one has ever supposed the first of these two substances to be formed in the oviduct. When the albumen deposited in the oviduct is spoken of, it is the white which surrounds the yolk of the egg of certain animals that is referred to, and it is altogether gratuitous to attribute to embryologists doubts on this subject. I think Mr. Desor is the only person who has ever confounded the albumen of the vitellus, with the albumen which *surrounds* the essential parts of the eggs common to all animals.

When mature eggs are to be referred to a uniform type, it is necessary to distinguish between the *essential* parts (the vitellus or yolk, the germinative vesicle and the germinative spot), and the *accessory and protective* parts (the external albumen or white, the shell-membrane and the shell itself). The former are identical throughout the animal kingdom, they are never wanting; they are therefore necessary. The latter are not absolutely necessary, and as a proof of this, they are modified according to circumstances, and, in an infinite number of cases, are entirely wanting.

Starting now from the structure of the egg and knowing it to be identical in its constituent elements throughout the whole animal kingdom, the doctrine of its crystallization from a *mother-liquid* refutes itself. The idea that the vitellus is precipitated, or is crystallized, is indeed very strange. Is not this the distinction which we make between the inorganic kingdom and the organic kingdom, that the former is *crystallized*, while the latter is *organized*.

And then as to the physical characters of this biogen liquid, and the method of distinguishing it from albumen, not a word is said. All that has been done is the substitution of a name, the thing newly named is hidden from the eyes of physiologists. To explain the formation of eggs in the animal kingdom, Mr. D. thus finds himself obliged to procure the intervention of a liquid of which he knows nothing,—a liquid which would make the function of the ovary of secondary importance,—a liquid which would substitute itself for the vital action of the organism, an action which physiology explains,—in fine, an occult liquid, which sound philosophy disowns.

To oppose such a liquid to the vital action of the organism in the procreation of the substance, from which new individuals arise, is to go out of the domain of science. Mr. D. moreover has found that his biogen liquid runs through various modifications. This liquid then has no permanent character, it is under the influence of something beyond it, which produces it in its turn.

Anatomy and physiology are our guides in our embryological researches;—one confirms the other. Remaining within these limits, it was not necessary to go beyond the bounds of sound philosophy, and to fancy a theory which rests upon nothing, which teaches nothing new, which explains nothing, and which stands apart, isolated from physiology.

Thus the theory of biogen, applied to the egg of Ascidia, is not even probable; applied to the animal kingdom it is absurd.

V. § 1. Prepossessed by the false notion that the vitellus is formed by condensation, Mr. D. compares the formation of eggs to that of the celestial bodies, according to the nebular hypothesis.

But in order that a comparison of one phenomenon with some other phenomenon may be established, it is necessary that the one with which the comparison is made, should be perfectly demonstrated,—it must be a law or a principle.

Now the author forgets that the question of the condensation of the heavenly bodies according to the nebular hypothesis, is one of the most controverted questions. The fact is that we know nothing positively respecting the origin of the stars. Has the matter of which they are composed, been diffused throughout space under the form of what has been called nebulæ, and

has it been gradually condensed around a nucleus to acquire its sphericity under the power of universal attraction, and to assume then a given movement and a determined direction?

There is no astronomer who can answer this question in the affirmative. From the study of our globe we arrive at the idea that it has had a beginning, and that it was originally in a fluid state. Beyond this, all is conjecture. Reasoning from the earth to the stars, we acknowledge, for all, a beginning of which we are ignorant.

It is then a false generalization to compare the phenomena of ovulation with the theory of the condensation of the sidereal bodies.

But let it be for a moment granted that the stars have been formed by the condensation of matter at first diffused. Where is the analogy between what ought then to take place, and what we witness in the formation of the egg?

The point of departure of organized beings is a sphere—the sphere is the figure of the celestial bodies; this is the whole of the analogy! In that sphere which constitutes the egg, two liquids are brought in contact and having an affinity for each other, they combine and form the vitellus which, from the first, is distributed equally throughout the whole sphere, less dense, it is true, at the beginning; but never showing the least tendency to centripetal motion, the least disposition to be precipitated around the germinative vesicle. There is never any retreat of the vitellus from the periphery towards the centre; there is no gravitation; there is a molecular attraction in the interior of a sphere, there are two liquids which are associated together, and not one liquid creating another out of itself.

Thus then should the theory of the condensation of the heavenly bodies be true, that of the eggs arising from *biogen* would not even be its analogue. Where is the biogen of the stars? No astronomer has had the hardihood to imagine a mother liquid, a gas, or any substance whatever preëxisting in space to create matter, and to disappear after having undergone various modifications.

§ 2. But Mr. D. stops not here. After having found *the great law of attraction at the bottom of the formation of organic bodies*, he comes to the question of movement. "As soon," he says, "as the egg enters upon its organic life, it begins to revolve." There are, indeed, a few invertebrated animals in which the embryo is subjected to a rotatory movement within the envelop of the egg. When one witnesses this for the first time, his thoughts naturally revert to the rotatory movement of the celestial bodies. But on looking deeper into the subject, he soon perceives the difference. I have described the movements which take place in the embryo of a marine Planaria.* I have shown that there is

* Proc. of the Amer. Assoc. for the Adv. of Sciences. Second meeting, held at Cambridge, August, 1849. Cambridge, 1850. 8vo, p. 400.

nothing regular about them, no subjection to law. The young animal itself regulates and controls them. There are vibratory ciliæ, that is to say, organs of locomotion, and where these do not exist, vibratory cells. There is not an external force under the dominion of which it is caused to move.

The egg possesses organic life from the moment when it appears under any form whatever, therefore it cannot be said to acquire it when it begins to move. Besides eggs, as eggs, move not; when they move they are no longer eggs; they are *embryos*. For when movement occurs it does not take place till after the division of the yolk; and after that division, the embryo exists.

So that in this view also, the comparison is false.

ART. XL.—*Note on Heteronomic Isomorphism;* by J. D. DANA.

IN the table on page 241, of this volume, the mineral Petalite is placed with the triclinic feldspars. The cleavages appear to correspond more correctly to a monoclinic form, although as far as now understood, not wholly analogous to the ordinary feldspars in direction. In the C atomic volume, as determined, it is identical with the monoclinic feldspars. The atomic volumes of the feldspars will then stand as follows:

	A.	B.	C.
I. MONOCLINIC.			
Orthoclase,	1388	231·3	60·4
Ryacolite,	867	216·7	57·8
Loxoclase,	1063	212·6	56·0
Baulite,	2178·1	217·81	55·85
Petalite,	6071·8	224·96	57·3
II. TRICLINIC.			
Albite,	1280·4	213·4	55·67
Labradorite,	795·5	198·9	53·03
Oligoclase,	1038·3	207·66	54·647
Andesine,	2912·4	208	55·0
Anorthite,	1959	195·9	52·94
Vosgite,	2266·5	197	52·84

Topaz and Andalusite approximately isomorphous.—The angle of the vertical prism of Andalusite is 91° 20′, and in Topaz there is the corresponding angle 93° 7′ (form $\propto \breve{P}2$, as usually taken). In the former, P : *a*, (a brachydiagonal prism,) = 144° 50′ Teschemacher, 140° Phillips, while topaz has the corresponding angle 138° 3′. Rammelsberg has recently suggested that in topaz the fluorine replaces oxygen, and that the formula is essentially $\dot{\mathrm{Al}}^3\ddot{\mathrm{Si}}^2$, with one-seventh of the oxygen replaced by fluorine, or as written out in full,

$$6[3\mathrm{Al}^2\,\mathrm{O}^3 + 2\mathrm{SiO}^3] + [3\mathrm{Al}^2\,\mathrm{F}^3 + 2\mathrm{Si}\,\mathrm{F}^3].$$

As this, excluding the fluorine, is the formula of Andalusite, the isomorphism here pointed out may be a case of ordinary isomorphism.

Manganocalcite.—This species is a trimetric carbonate of manganese, illustrating the remark on page 239.

Art. XLI.—*On some Minerals recently investigated by M. Hermann*;* by James D. Dana.

1. Gibbsite.

The analyses of Gibbsite by Hermann, according to which Gibbsite is a phosphate instead of a hydrate of alumina,* are alluded to by Prof. Silliman, Jr., in his memoir, in volume vii, of this Journal, page 411, where this chemist, by several analyses, sustains the original view with regard to this species, his results giving much less than one per cent. of phosphoric acid. Hermann in a late memoir† publishes the following as his recent conclusions upon the Richmond mineral.

	1*a*.	1*b*.	2.	3.
Phosphoric acid, . .	37·62	26·30	15·30	11·99
Alumina, ...	26·66	38·29	50·20	53·92
Water, ...	35·72	35·41	34·50	34·18

Nos. 1*a* and 1*b* were two specimens somewhat foliated on limonite; G.=2·21. No. 2 was a stalactitic mass; G.=2·44. No. 3 was porous with an earthy fracture; G.=2·20. The phosphoric acid is here made a very varying constituent.

This species, from Richmond, has recently been analyzed by Mr. Crossley in the Laboratory of Dr. C. T. Jackson, with direct reference to the occurrence of phosphoric acid (as in Prof. Silliman's investigations), and he has found that his specimens *contained no phosphoric acid, and were a true hydrate.* The mineral is therefore identical with Rose's hydrargillite and includes that species, as has been before suggested.

2. Willemite, or Anhydrous Silicate of Zinc.

The anhydrous silicate of zinc was first recognized as a species by Vanuxem and Keating, who published a full and accurate description both physical and chemical, in 1824, in the Journal of the Academy of Natural Sciences of Philadelphia, volume iv, page 8. They describe the form of the crystals, as occurring at Stirling, New Jersey, and give the angle R : R, 118°, which was offered as only an approximation, the faces being irregular and rough.

Subsequently, Dr. Thomson of Glasgow received specimens. He described the mineral physically nearly as done by Vanuxem and Keating,‡ mentioning the hexagonally prismatic form with trihedral summits, though giving the angle 124° instead of 118°, observing however that it was "impossible to measure the angles," as the planes were so very uneven. He states that the

* Jour. für Prakt. Chem., xl, 32. † Ibid, xlvii, 1.
‡ Ann. Lyceum Nat. Hist., N. Y., iii, 1828, and Mineralogy, 1836, i, 519.

above-mentioned authors had made it out a *silicate of zinc.* His investigations transformed it into a silicate of manganese with the composition

$\ddot{S}i$ 30·650 $\dot{M}n$ 46·215 $\dot{F}e$ 15·450 moisture and carbonic acid 7·300=99·615.

Dr. Thomson's reputation at that time served to put the blunder on Vanuxem and Keating. The mineral was named Troostite, and Thomson's analysis assumed as the correct one. Recently the so-called Troostite has been examined by Hermann,* who has confirmed the original analyses, both results giving the formula $\dot{Z}n^3\,\ddot{S}i$ = Silica 72·47, oxyd of zinc 27·53, or the constitution of Willemite. The analyses hitherto made of the American and foreign Willemite are as follows:—

1, 2, Vanuxem and Keating (loc. cit.); 3, Hermann (loc. cit.); 4, Thomson (Min. i, 545); 5, Levy (Ann. des Mines, [4], iv, 515); 6, Rosengarten (Rammelsberg's 3d Supplement to his Handwörterbuch, 65); 7, 8, Monheim (Verh. Nat. Vereins. Rheinl., 1848, and Rammelsberg's 4th Supplement, 114); 9, 10, Delesse (Ann. des Mines, [4], x, 211).

	$\ddot{S}i$	$\dot{Z}n$	
1, Stirling,	25·44	68·06	$\dot{F}e$, $\dot{M}n$ 6·50 = 100·00, Vanuxem and Keating.
2, "	25·00	71·33	$\dot{F}e$ 0·67, $\dot{M}n$ 2·66 = 99·66 " "
3, "	26·80	60·07	$\dot{M}n$ 9·22, $\dot{M}g$ 2·91, $\dot{F}e$ *trace*, loss by ignition 1·0=100 Herm.
4, Moresnet,	26·97	68·77	$\dot{F}e$ 1·48, $\ddot{A}l$ 0·66, ib. & trace $\dot{Z}n$, $\dot{F}e$ 0·78, $\dot{H}$ 1·25=99·91, Thom.
5, "	27·05	68·40	$\dot{F}e$ 0·75, loss by ignition 0·30 = 96·50, Levy.
6, Silesia,	27·34	70·82	$\dot{F}e$ 1·81 = 99·97, Rosengarten.
7, Stolberg,	26·90	72·91	$\dot{F}e$ 0·35 = 100·16, Monheim.
8, "	26·53	69·06	4·36, $\dot{C}a$ 0·41, $\dot{M}g$ 0·13, $\dot{C}$ 0·04 = 100·53, Monheim.
9, "	27·28	72·37	$\dot{F}e$ 0·35 = 100, Delesse.
10, Stirling,	27·40	68·83	0·87, $\dot{M}n$ 2·90 = 100, Delesse.

Hermann gives the specific gravity of the Stirling ore 4·02; Vanuxem and Keating 3·89–4; Thomson for the Willemite 3·935, and Levy 4·16–4·18. No. 7 (from Stolberg near Aix la Chapelle) was crystallized; G. = 4·18. No. 8 massive; G. = 4·02–4·16. No. 10, the Stirling mineral, according to Delesse, has G. = 4·154.

The crystals of Troöstite have besides the primary rhombohedron (115°) another truncating its terminal edges, $(-\frac{1}{2}\,R)$ with R : R = 142° 52′. The crystals of Willemite are quite small, being but 2 or 3 millimeters long and 1 thick. They are hexagonal prisms, but the prism is intermediate to that of Troostite; and the trihedral summit has according to Levy the angle of 128° 30′ nearly, the planes not admitting of very accurate measurement,—corresponding possibly to the rhombohedron $\frac{3}{4}R$, which has this angle 127° 33′.

* Jour. für prakt. Chem. of Erdmann and Marchand, xlvii, 11.

3. Rhodonite, or Manganese Spar.

Rhodonite was long since shown to be a manganese augite, and the Fowlerite of Shepard is recognized by Hermann as giving the angle of augite; M : M = 87° 6′. Hermann has analyzed the Stirling, N. J., mineral with the following result,

	$\ddot{S}i$	$\dot{F}e$	$\dot{M}n$	$\dot{Z}n$	$\dot{C}a$	$\dot{M}g$	
	46·48	7·23	31·52	5·85	4·50	3·09	loss by ignition, 1·00 = 99·67
Oxygen,	24·13	1·60	7·06	1·15	1·28	1·22	

giving for the oxygen ratio for protoxyds and silica 12·31 : 24·13, or very nearly 1 : 2, as in the received formula $\dot{M}n^3\ddot{S}i^2$. He obtained the specific gravity 3·63.

Hermann has also analysed the manganese spar of Cummington, Massachusetts, and has concluded that the mineral instead of being a manganese augite is a manganese hornblende, that is, has the oxygen ratio 4 : 9 and formula $\dot{M}n^4\ddot{S}i^3$.

His analysis gave

	$\ddot{S}i$	$\dot{M}n$, *trace* of $\dot{F}e$	$\dot{C}a$	$\dot{M}g$
	48·91	46·74	2·00	2·35 = 100·00
Oxygen,	25·38	10·37	0·57	0·91

The result affords the oxygen ratio for protoxyds and silica 11·85 : 25·38 or very closely 4 : 8½, which is as near augite as the hornblende ratio. He unites with his *mangan-amphibol*, Thomson's sesquisilicate of manganese from Stirling, which according to Thomson has the angle 123°30′, which is nearly that of hornblende. But Thomson's analysis proves the crystallographic measurement of little value, since it makes the species a *mangan-augite*—it giving

$\ddot{S}i$ 42·40 $\dot{M}n$ 50·72 $\dot{F}e$ 6·76

or even less silica than required for an augite, instead of the excess which would make it a hornblende.

The mineral of Cummington often contains disseminated through it visible points or grains of silica, and if in visible grains, there will be also invisible silica, and enough to account probably for the hornblende composition. M. Adolph Schlieper, now of Lowell, Mass., has examined and analyzed the Cummington mineral, from specimens placed in his hands by the writer, and he attributes the excess of silica to this source. His analysis gives the oxygen proportion 11·36 to 26·6, or quite closely 4 : 9. He found the mineral to be partly soluble in acids and by this means separated it into an *insoluble* portion 90·15 per cent., a *soluble* 9·85.

The insoluble part afforded

	$\ddot{S}i$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$	$\dot{F}e$
	51·21	42·65	2·93	*trace*	4·34 = 101·13
Oxygen,	26.6	9·56	0·84		0·96

The soluble part consisted of carbonates as follows,

$\dot{M}n\ddot{C}$	$\dot{F}e\ddot{C}$	$\dot{C}a\ddot{C}$	$\dot{M}g\ddot{C}$	$\ddot{H}$ and loss.
50·52	8·60	37·17	2·44	1·27 = 100

The presence of carbonic acid in this mineral was long since announced by Hitchcock, who found ten per cent. in one specimen. If the uncombined silica bears any proportion to the invisible carbonates, the excess of this ingredient is sufficiently explained. We believe therefore with M. Schlieper, the mineral to be essentially identical with the mangan-augite.

4. Lepolite and Lindsayite.

The Lepolite of Hermann* is a feldspathic mineral from Finland, identical in chemical formula with anorthite, but differing in having its crystals oblique or inclined to the *left*, (when the edge T : T′ is in front) instead of to the *right*. He gives for T : T′ 120°30′, P : M 93°, which is the angle between two cleavage planes. H = 6. G = 2·75–2·77. Vitreous and transparent; colorless, grayish, greenish, often brownish externally. Crystals often large, and sometimes two inches long. Composition $\dot{R}^3\ddot{S}i+3\ddot{A}l\ddot{S}i$.

	$\ddot{S}i$	$\ddot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	loss by ignition.
1. From Lojo,	42·80	35·12	1·50	14·14	2·27	1·50	1·56=99·69
2. From Orrijervi,	42·50	33·11	4·00	4·00	5·87	1·69	1·50=99·54

It fuses with difficulty on the edges before the blowpipe, and is decomposed by concentrated acids.

Hermann has also published a description of a new feldspar which he calls *Lindsayite*† in the same memoir with the Lepolite. The following are its characters:

Monoclinic or triclinic, T : T′ = 120°, P on the axis 65°. Crystals often of large size. H. = 4. G. = 2·83. Color, black externally, internally gray, bluish-gray, dull reddish. Subtranslucent. In a matrass yields water. Before the blowpipe fuses with difficulty on the edges. With the fluxes, the reaction of iron and silica. Analysis afforded,

	$\ddot{S}i$	$\ddot{A}l$	$\dot{F}e$	$\dot{F}e$	$\dot{M}g$	$\dot{K}$	$\dot{N}a$	$\dot{H}$	
	42·22	27·55	6·98	2·00	8·85	3·00	2·53	7·00	$\dot{P}$ *trace* = 100·13
Oxygen ratio	21·90	12·84	2·09	0·44	3·49	0·50	0·64	6·22	

whence he deduces for the oxygen of the water, protoxyds, peroxyds and silica, the ratio 1 : 1 : 3 : 4, and the formula‡

$$\dot{R}^3\ddot{S}i+3\ddot{A}l\ddot{S}i+3\dot{H},$$

which, excluding the water, represents the composition of anorthite and also Hermann's lepolite.

Breithaupt, in volume xlvii, p. 236, of the Journal für praktische Chemie, stated that the Lindsayite was properly a pseudomorph, after lepolite. To this view Hermann objects in volume xlviii, 254, (Nov. 1849,) mentioning that lepolite contains 10 to 15 per cent. of lime and lindsayite none.

* Jour. f. prakt. Chem., xlvi, 387. † Jour. f. prakt. Chem., xlvi, 396.

‡ This is only an approximation; for the oxygen of the peroxyds and silica has more nearly the ratio 2 : 3 than 3 : 4.

The constitution of the mineral, so different from all known feldspars—its 8 per cent. of magnesia, 7 per cent. of oxyd of iron, and 7 per cent. of water—entirely favor the opinion that the crystals are actually pseudomorphs of some feldspar mineral as Breithaupt suggested. Changes through pseudomorphism of the extent this would imply, and even far greater, are abundantly exemplified.

ART. XLII.—*On the Interpretation of Mariotte's Law;* by Lieut. E. B. HUNT, U. S. Corps of Engineers.

IT is readily demonstrated that in any entirely *homogeneous* medium, the component parts of which act on each other by forces varying as any function of the distance, Mariotte's law must prevail. Both elastic tension and cohesive force will necessarily vary as the density, in a medium assumed as homogeneous, quite irrespective of the law of force, the variation being expressed in terms of distance between the component parts of the medium. Whether the force be attractive or repulsive, varying inversely with the first or hundredth power of the distance, the result is the same; that *entire homogeneousness makes Mariotte's law necessary.*

To prove this: assume a perfectly homogeneous medium whose parts exert forces varying as any function of the distance. Assume in this an origin of coördinates, three coördinate axes, X, Y and Z, and three constant elementary distances, dx, dy, dz. Conceive each axis graduated by laying off its element successively from the origin outward. Through each point of graduation on either axis pass a plane parallel to the other axes: do this for each axis. The space around the origin is thus divided into elementary parallelopipeds, each of which contains a like portion of the homogeneous medium.

The force of elastic tension or of cohesion is measured by the resultant action on a unit of surface of the plane X, Y, by all the forces acting in the positive direction of the axis Z, between the parts on opposite sides of the plane X, Y. This resultant is balanced by an equal one acting in the negative direction of the axis Z. To make up this resultant, a certain number of the elementary portions of the medium conspire. It may therefore be equated with a series, each term of which expresses the positive component along the axis Z, of the force exerted between two elementary portions of the medium on opposite sides of the plane X, Y.

If now the density of the medium be varied, each term of this series will vary in the same ratio, since the quantity of matter in

each elementary volume varies as the density. The density thus governs each term of the series, by fixing the quantity of matter in each elementary volume. If we call the ratio of the varying density to a standard density N, each term of the series contains N as a simple factor: or the whole series varies as N. Hence the resultant or entire elastic tension or cohesion varies as N, or as the density. This result is entirely independent of any particular law of relation between the forces and distances: and will always be true so long as the elementary volumes can be assumed as homogeneous. As dx, dy, dz, can always be taken indefinitely less than the radius of sensible activity of any assumed force, the demonstration can only fail by the parts failing to be homogeneous.

It will be seen by the above that any inference of the law of repulsive force between ultimate atoms or molecules, cannot be correctly drawn from Mariotte's law, for this leaves the primary forces involved, wholly indeterminate. We are by no means authorized to conclude that in elastic fluids where the pressure varies as the density, the molecules repel each other directly as the distance.

The demonstration now given, has a singular bearing on the atomic theory of material constitution. We know experimentally that Mariotte's law does not prevail uniformly in elastic media, while in liquids and solids it has no show of application. Hence we are bound to infer *non-homogeneousness*. Now how can homogeneousness be interrupted, except through something like an atomic constitution of media? A laminated, filamental, or molecular structure alone can produce heterogeneousness. The two first would confer special properties in certain directions, which are not found in fact. Hence a molecular constitution of matter seems entailed as an inference, from the bare fact that Mariotte's law is not universal. According to the view now presented, the elasticity of gases varies as the density, because the quantity of matter within the sphere of sensible activity varies in that ratio. As they approach the point of liquefaction, other considerations derived from the special atomic constitutions of the media must be introduced. The entire absence of a limit to the division of parts would produce that homogeneousness from which Mariotte's law becomes an inevitable inference. Such an inference, as applied to media in general, being contrary to the fact, a limit to actual division of parts must be admitted. ***Any other theory than one of ultimate molecules, separated by spaces, seems to impose inferences conflicting with facts, throwing us back irresistibly into the theory of true molecular structure.***

Boston, April, 1850.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Deportment of Crystalline Bodies between the poles of a Magnet;* by John Tyndall and Hermann Knoblauch; (Phil. Mag., xxxvi, 178, March, 1850.)—The results obtained by Professor Plücker of Bonn, in his investigations upon crystals, induced us early in the month of November last to commence a series of researches in connection with this subject. Our inquiries, so far as they at present reach, form the subject of this paper.

After a long series of trials, not necessary to be recapitulated here, we arrived at the persuasion that no safe inference could be drawn from experiments made with full crystals. It appeared necessary to examine the forces attributed to crystalline bodies in detail, one at a time, removing as far as possible all influences likely to interfere with the simple action of this one.

To attain this object we experimented with cubes: we had one cut from tourmaline, in such a manner that the optical axis of the crystal ran parallel to four sides of the cube; on suspending it between the poles and closing the circuit, the optical axis set itself strongly equatorial; thus corroborating the law of Plücker, which affirms that the optical axes of negative crystals are repelled. When, however, the same cube was hung with the optical axis vertical, the influence of that axis being thus destroyed, a preference was shown to one of the diagonals of the horizontal face of the cube, not to be explained by the law mentioned: this preference was more strikingly exhibited in the case of the following two crystals.

A cube of beryl, cut similarly to the tourmaline, being hung with its optical axis vertical, one diagonal of its horizontal face set itself axial; only one diagonal could maintain this position, the other was repelled. In dichroite this phenomenon was strikingly exhibited; when hung with the middle line of the optical axes vertical, one diagonal assumed the axial position; if, however, the circuit was closed when the other diagonal chanced to lie from pole to pole, the latter seemed to experience a repulsive shock, sufficient to make the cube spin several times round upon its axis.

We do not see any possibility of referring this election of a particular diagonal to the influence exerted by the optical axis, at least in the case of beryl.

To ascertain the exact nature of this influence, we had recourse to discs, cut so that the optical axis of the crystal lay as a diameter in the plane of each. In this way the influence of mere form was totally annulled, and the pure action of the optical axis, if such existed, might be observed.

Our first discs, five in number, were taken from a semi-transparent crystal of Iceland spar, and lay at various angles to the sides thereof. In all these cases the law of Plücker was strictly verified, the optical axis being always repelled.

Four discs and one square were next taken from two transparent crystals of the spar, and suspended successively between the poles. We were by no means prepared for the reply given to these experiments; *in each of the five cases the optical axis set itself distinctly axial.*

The balance sheet of our inquiries up to the present time is this; out of eleven crystals of Iceland spar examined as above, five have obeyed the law of Plücker, while six have contradicted that law.

In determining whether the optical axis will be repelled or not, it is not necessary to cut the crystals in the manner described. A thin rhomb cloven from the crystal and ground into the shape of a disc, will decide the question. If it belong to the class whose optical axis is repelled, the line bisecting the acute angles of the rhomb will set itself axial; if to the other class, the same line will set itself equatorial.

Discs thus prepared form undoubtedly the purest means of investigating this question. The rhomb itself, however, without being ground into a disc, affords us sufficient intelligence as to the class of the crystal to which it belongs. Is its optical axis repelled, then the long diagonal of the rhomb will incline to the axial position; is the optical axis attracted, the long diagonal will stand nearly equatorial.

The same adherence of the diagonal to the axial or equatorial position continues after a thin bar containing the diagonal has been severed from the rhomb. For example, a bar containing the short diagonal of that class whose optical axis is attracted, will stand nearly axial. This fact is perhaps worthy of notice: if Iceland spar be diamagnetic, as Prof. Plücker asserts, and if the optical axis be repelled, what is it that overcomes the united action of both in the case of this diagonal? The projection of the optical axis lies in the same direction as the bar; both therefore work together, and both strive, in virtue of the two properties mentioned, to attain the equatorial position; they do not attain it, however; the bar stands almost axial.

The question, "Is the substance magnetic or diamagnetic?" necessarily lay at the threshold of all attempts to explain these phenomena. To answer this question by experimenting with the full crystal was impossible, as a diamagnetic crystal, it is well known, can set itself axially. This being evidently owing to some hidden property of the crystalline structure, we thought it might be destroyed by reducing the mass to powder. Portions of crystals of each class were finely pounded in an agate mortar; by the addition of a little distilled water the powder was made into a paste, from which small bars were constructed and carefully dried. On being hung between the excited poles, those whose optical axes were repelled stood equatorial, the others axial.

Adopting the plan already followed by Faraday, we next brought the two classes of crystals to the test of a single pole. At first, little bits of crystal were attached to the cocoon thread by means of a soft sticky kind of wax; the presence of this, however, was found to interfere with the purity of the experiment, and it was therefore abandoned; fine silver wire was next tried and also found ineligible; we next hung a straw horizontally, into each end of which a bit of crystal was thrust; but the straw was diamagnetic, and permitted no safe conclusion. Common white taper-wax was at length found exactly suited to our purpose;

it must, however, be handled with clean fingers, and even thus very little; after two or three suspensions it invariably showed signs of magnetism. We chose long thin bars of crystal and hung them vertically thus bringing the wax so far above the poles, that, on examination, it showed not the slightest trace of magnetism or diamagnetism. A former remark explains why this vertical hanging is to be preferred to horizontal; in the latter case, a rotation towards the pole, easily mistaken for an attraction, and difficult to distinguish from it, might occur with a diamagnetic body; hung vertically, however, it could be distinctly seen whether the *mass* of the crystal was attracted or repelled. The results here delivered were in harmony with those already mentioned: those whose optical axes were attracted, were attracted; those whose optical axes were repelled, were repelled.

Anxious to investigate this difference of action to the bottom, we chose two perfectly pure and transparent crystals from each class, and submitted them to chemical analysis. An experienced mineralogist was unable to detect the slightest visible difference between these crystals; the analysis, however, showed that those whose optical axes were attracted contained protoxyd of iron in considerable quantity, while those whose optical axes were repelled contained no trace of this metal.

Here, then, we have two crystals perfectly alike in optical respects, but chemically different; the change in the position of the optical axis between the poles being doubtless due to this difference. This seems to reduce that position to a mere function, so to speak, of the chemical nature of the substance. Could a salt of iron be introduced as an isomorphic substitute for some other constituent in the whole class of diamagnetic crystals, it is exceedingly probable that the position of the optical axis between the poles would in most of these cases be reversed, and this without in the slightest degree interfering with the optical properties of the crystal. It is even likely that Nature, as in the case before us, furnishes many examples of this isomorphic substitution. If this be true, then the position of the optical axis between the poles is a mere accident, and the introduction of it can only serve to render this already difficult subject unnecessarily complex.

On bringing a circular disc of gutta percha, which, in its manufacture, appeared to have a fibrous structure imparted to it, between the excited poles, the direction of these fibres set itself strongly axial. This action was so decided, that a parallelogram, three-quarters of an inch long and half as wide, with the fibres crossing it transversely, set itself stiffly equatorial. This can by no means be referred to the distance of the parallelogram from the poles, or to any other of those circumstances by which diamagnetic action is said to be exhibited; our voltaic power varied from one to twenty cells of Bunsen's battery, but the result remained specifically constant; further, on being hung edgeways, the parallelogram stood strongly magnetic; and when one pole was removed, the whole mass was attracted by the other.

Whence, then, this apparent diamagnetism of the gutta percha? The answer to this question will perhaps throw a light upon the complicated phenomena exhibited by crystals generally. The equatorial position of the gutta percha is manifestly due to the comparative facility with which the magnetic force can act in the direction of the fibre. Let us

suppose the parallelogram suspended, and the circuit closed; every point of its substance is now affected, but not with equal force in all directions; in the direction of the fibre the action is strongest, and may be represented by the longer diameter of an egg, in the centre of which the point may be imagined. All lines drawn from the centre to the shell will represent the amount of the magnetic force in their various directions. On this assumption the equatorial position is readily explained; and the necessity of the parallelogram, when hung edgeways, to set itself axial, is also manifest.

As may be expected, when the parallelogram is made very long in comparison to its width, the long diameter of our hypothetical egg, is overpowered by the united action of a number of short ones, and the oblong stands axial.

We have succeeded in obtaining analogous results with ivory, which, though diamagnetic, can be so cut that it stands almost axial. The anomaly is explained by reference to the structure of the tooth, which modifies, in certain directions, the diamagnetic power. By attending to these circumstances, we have been able, with these two substances, gutta percha and ivory, to imitate almost all the experiments which we have made with both classes of crystals.

If we suppose the shorter diameter of an ellipse to coincide with the straight line formed by the intersection of any two surfaces of cleavage, and the ellipse to rotate around this diameter, an oblate spheroid will be the result. Conceive lines drawn through the centre of this figure and terminated by the surface, to represent the amount of magnetic or diamagnetic force in the direction of these lines, and we have an hypothesis of magnetic or diamagnetic action within the crystal, sufficient, not only to account for every fact noticed in this paper, but for numerous others, the discussion of which we refer to a future occasion.

Extending this principle to the intersections of the three surfaces of cleavage, we obtain a resultant which falls in the direction of the principal axis of the crystal, or of the optical axis. The position of that resultant between the poles will depend solely upon the magnetism or diamagnetism of the crystal, and in nowise upon the fact of its being negative or positive, as asserted by Professor Plücker.

It is highly improbable that our representative spheroid will be of a constant shape in all crystals: in the case of gutta percha we assumed it formed by the rotation of a semi-ellipse round its longer axis, or what is commonly called prolate; in the case of Iceland spar it is oblate; in common iron it would be a sphere, as here the magnetic force appears to act equally in all directions. Every crystal will doubtless modify it in a manner peculiar to its own substance and structure. Future experiments will perhaps enable us, in many cases, to determine the numerical values of the long and short diameters of these spheroids.

From these considerations it would follow, that M. Plücker, in attempting to refer the facts observed by Mr. Faraday* to the optical axis, inverts the right course of proceeding; the attraction or repulsion of this axis being a secondary result, depending first of all upon the mag-

* Phil. Mag., Jan., 1849, p. 75.

netism or diamagnetism of the substance, and secondly upon the manner in which either force is modified by the peculiar structure of the crystal.

The conducting power, so to speak, of Iceland spar for both magnetism and diamagnetism appears to be in directions perpendicular to the lines of cleavage. If these views be correct, the optical axis can no longer be regarded as the prime agent in the production of the phenomena which we have been considering; we shall no longer seek the explanation of new facts in the hypotheses of new forces, but rather in modifications of the old.

Marburg, January, 1850.

2. *Arsenic in the deposit from Mineral Waters;* by M. J. L. Lassaigne, (Journ. de Chem. Med., Sept., 1849; Phil. Mag., Dec., 1849.)—The large quantities of arsenic recently discovered in certain chalybeate waters, have made it a matter of much interest to determine the state in which the arsenic exists, and its effects upon the animal economy.

The deposit from the waters of Wattvillier (Haut Rhine) yielded 4·42 per cent. of arsenic acid, equivalent to 2·8 per cent. metallic arsenic. Forty grammes (about 600 grains) of this deposit were administered to a dog in two doses, the animal showed not the slightest uneasiness, ate as usual, and, in short, was uninjured by a dose equivalent to 26·52 grains arsenic acid or 16·8 grains metallic arsenic.

From this and another experiment of similar character, the author infers, that the poisonous property of the arsenic is destroyed in these deposits by the combination with peroxyd of iron—confirming the value of peroxyd of iron as an antidote to arsenious and arsenic acids.

[It is worthy of remark, however, that the recent deposit from chalybeate water is not without serious effect upon the human system, as is shown by the following case which was brought to our notice. Two gentlemen while drinking the water of a celebrated chalybeate spring thought to add to its strength by mixing with it several teaspoons full of the fresh deposit. In a very short time such alarming symptoms manifested themselves as to require medical aid. These symptoms were violent headache, throbbing in the temples, &c., and were evidently due to an over dose of iron. The parties soon recovered, but in the more plethoric of the two the effects were sensible for several days.

The same quantity of *dry* peroxyd of iron—such as is erroneously called carbonate of iron, might have been taken with impunity. No more striking instance of the difference in effect between the moist freshly precipitated oxyd and the dry could be given.]

G. C. Schaeffer.

3. *On the reduction of Chlorid of Silver;* by M. Wittstein, (Buch. Rep., vol. ii, in Chem. Gaz., Sept., 1849.)—The author prefers the reduction by charcoal. Two parts of chlorid of silver are well mixed with one part moist charcoal powder and poured into a black lead or other crucible with a smooth surface. The crucible is loosely covered and ignited until a quarter or half hour after the muriatic acid has ceased to appear. The outside of the crucible being cleaned it is to be inverted over a sheet of paper, and if any of the contents adhere they may be removed with a feather. The carbonaceous mass is then gradually added to 3 parts nitric acid, sp. gr. 1·20, in a convenient flask, and the solution is completed by a gentle heat.

As it is not easy to extract the whole of the silver, the mass need not be washed very long and the residuum may again be employed in another process to avoid loss. The impurities derived from the charcoal are trifling in amount; lampblack of course answers still better.

The author considers that the reduction is effected in reality by hydrogen, as only muriatic acid and no chlorine is given off.

G. C. S.

4. *On the Chemical Composition of the Fluid in the Ascidia of Nepenthes;* by Dr. A. VOELCKER, (Phil. Mag., Sept., 1849.)—The fluid of this, and similar secretions as in Sarracenia, &c., is commonly said to be pure water. Dr. Turner found on evaporating, a minute quantity of crystals supposed to be binoxalate of potash, while the odor of boiled apples given out indicated the presence of organic matter. The author examined eight different samples from various gardens and in most cases from unopened pitcher plants. In all the cases litmus paper gave an acid reaction. The same odor as that mentioned by Dr. Turner was observed during evaporation. The quantity of solid matter, as might be expected, varied considerably—from ·27 to 1 per cent. No volatile acids were present and no oxalic acid.

The dry residue from several samples united, contained about 38 per cent. of malic and a little citric acid, 50 p. c. chlorid of potassium; the remainder consisted of soda, lime and magnesia.

These experiments show this to be, as botanists have already demonstrated, a true secretion, containing *some* of the inorganic materials of the plant; but it is remarkable that not a trace of sulphuric acid could be detected, and yet it is hardly possible that sulphates are entirely wanting in the plant. G. C. S.

5. *Chlorine and Oxygen from Chlorate of Potash;* by Dr. VOGEL, (Buch. Rep., vol. iii, in Chem. Gaz.)—The author states that chlorate of potash repeatedly crystallized furnishes a pure gas, and ascribes the impurity to the presence of some perchlorate (hyperchlorite?).

[It is generally understood that oxygen from the mixture of peroxyd of manganese and chlorate of potash, is always contaminated with more or less chlorine, in which case the above precaution would be of no use.

The supposed easy preparation of pure chlorate is at the foundation of numerous determinations of chemical equivalents, and in particular that of chlorine.] G. C. S.

6. *Action of Potash upon Caffeine;* by A. WURTZ, (Comptes Rendus, Jan., 1850.)—A boiling concentrated solution of potash dissolves caffeine and disengages a considerable quantity of methylamine.

This confirms the supposition made in the last No. of this Journal, p. 282, that the base formed by Rochleder in the decomposition of caffeine by chlorine was methylamine. M. Wurtz also notices that the composition of the platinum salt is identical with that of the corresponding platinum salt of methylamine. G. C. S.

7. *Separation of Butyric, Valerianic and Acetic Acids;* by J. LIEBIG, (Liebig's Annalen, Sept., 1849; Chem. Gaz., Jan., 1850.)—The simultaneous occurrence of these acids renders an easy and economical process for their separation exceedingly desirable. This desideratum is fully answered by the plan proposed by Prof. Liebig. A part of the mixture of acids is saturated with potash and soda, or the re-

mainder added to it and distilled. If butyric and valerianic acids only are present, a portion of one or the other is at once obtained pure. If the alkali added is not sufficient to neutralize the whole of the valerianic acid, the distillate is a mixture, and the residue is a pure valerianate. If the alkali is more than sufficient to neutralize the valerianic acid, the residue is a mixture of valerianic and butyrate, but the distillate is pure butyric acid.

The mixtures remaining may be treated in the same way, and a new portion obtained pure.

Acetic acid, although more volatile than the other two, is not expelled by them from a partially saturated solution, owing to the formation of an acid acetate. Either valerianic or butyric acid may be distilled from this salt without intermixture with acetic acid. Where all these acids are present, the partially saturated mixture is to be distilled, and if any acetic acid is found in the distillate the process is to be repeated. Acetic acid is thus removed and the other two may be separated as above.

G. C. S.

8. *On the Production of Organic bases from Vegetable substances containing Nitrogen;* by Dr. J. STENHOUSE, (Liebig's Ann., May, 1849; Chem. Gaz., Oct. and Nov., 1849.)—Reasoning upon the fact that fossil coal has yielded four bases besides ammonia—the author proposed to examine the products of the dry distillation of nitrogenous vegetable matter, and as these substances could not easily be obtained pure in large quantity, he operated directly upon seeds, &c., which are known to contain most of the nitrogen of plants. A large quantity of common beans was distilled in an iron retort. The product resembled that from animal matters, containing acetone, acetic acid, &c., with tarry matter and a large quantity of ammonia and oily bases. These latter were, with some difficulty, obtained in a state of purity, but the result was an evident mixture, the boiling point rising from 226° F. to 428°. The larger portion passing over between 302° and 311°, a tolerable quantity of an oil of constant boiling point was obtained.

Notwithstanding the difference in the bases indicated above—their properties are otherwise quite similar. They are colorless and transparent, of high refractive power, with pungent aromatic taste and odor. The more volatile are also more soluble in water, but all of them dissolve readily in alcohol and ether. The alkaline reaction upon test paper is very strong, and a rod moistened with hydrochloric acid held over them produces white fumes. The salts are generally crystalline; the double platinum, gold and mercury chlorids are readily obtained; not a trace of aniline could be detected.

The analysis of the oil boiling between 302° and 311°, gave the formula C_{10} H_8 N, but this must be considered only as an approximation. The formula is nearest to that of nicotine; but the properties are rather those of picoline, discovered by Dr. Anderson.

An examination of oils boiling at very different temperatures, gave almost the same per-centage of carbon and hydrogen. May not some of these be merely polymeric modifications of the less volatile bases?

Oil cake required a higher heat for its distillation than the bean, and a smaller quantity of bases was obtained; wheat furnished a still smaller quantity, but the product was more volatile. Peat gave a larger

quantity, but the products of the distillation of solid wood furnished hardly any.

To avoid the high heat necessary in distillation, by which the bases are decomposed, and the quantity of ammonia increased—experiments were made by boiling the substances with alkaline solutions; the products were nearly the same but more free from impurity. Flesh and guano were also tried, and the action of sulphuric acid upon beans, with like results.

The author proposes putrefaction as a still more eligible process for the alkaloids, as the action is less energetic. The fact that beans and bones do not yield the same products by distillation, is adduced as evidence that the vegetable and animal substances having the same composition are yet not identical. G. C. S.

9. *Preparation of Hydrobromic and Hydriodic Acids;* by E. H. Mène, (Comptes Rendus, April, 1849; Chem. Gaz., July, 1849).—The process now proposed for these two acids is free from objection, being neither costly, difficult nor dangerous, as are the usual modes.

In this process, crystallized hypophosphite of lime, obtained in preparing phosphuretted hydrogen from phosphuret of calcium, may be used, but from its being more readily obtained, sulphite of soda is to be preferred. The crystallized sulphite is to be first dipped in water and the iodine or bromine added to it in a suitable vessel. The reaction is aided by heat, and the gases are obtained pure, if a cotton or asbestus plug is placed in the neck of the vessel to intercept vapors of bromine or iodine.

The sulphite aids the decomposition of water by the iodine or bromine, the latter taking the hydrogen, the former the oxygen.

The proportions for the above process are 1 water, 3 iodine or bromine, 6 crystallized sulphite of soda. G. C. S.

10. *Passage of Hydrogen Gas through solid bodies;* by M. Louyet, (Ann. de Chim. et de Phys., Sept., 1849.)—M. Louyet, finds that a horizontal current of hydrogen from a capillary jet under a pressure of 40 to 45 inches of water, will pass through a sheet of paper, continuing as a current on the other side, inflaming or igniting spongy platinum, as if no obstacle existed.

Gold, tin and silver leaf, even when double, exhibit the same property, as also a thin film of gutta percha; but the thinnest glass which could be blown was found impermeable. G. C. S.

11. *On the presence of Silver, Lead and Copper in Sea-water, and in Plants and Animals;* by MM. Malaguti, Durocher and Sarseau, (Comptes Rendus, Dec., 1849; Phil. Mag., Feb., 1850.)—MM. Malaguti and Durocher having proved the wide diffusion of silver in metallic minerals, particularly in the sulphurets, which are converted by salt water into chlorids, the present research was undertaken with a view to ascertain the extent of the distribution.

Sea-water taken at a distance of some leagues from St. Malo, was found to contain ·000,000,001 of silver; the ash of Fucus serratus and ceramoides contained ·000,001. Rock salt of Lorraine was found to contain silver, indicating its presence in the ancient ocean.

This wide distribution of the metal induced a search for it in the ashes of terrestrial plants and in animals, the blood of them being satu-

rated for the experiment. In both cases silver was found. Its presence could not be distinctly proved in the ashes of coal.

Lead and copper could not be detected in sea-water, but the ashes of several species of Fucus contained ·000,018. G. C. S.

12. *Ruthenium.*—The atomic volume of Ruthenium has been found by Claus to be identical, or nearly so, with that of Rhodium, or 651·96, see table, page 220.

II. Mineralogy and Geology.

1. *Description of the Vermiculite of Milbury, Mass.;* by Dr. C. T. Jackson, with an analysis by Mr. Richard Crossley, (communicated by Dr. Jackson.)—This mineral was first noticed in Milbury by Dr. Thomas H. Webb of Providence, R. I., and was described by him in the American Journal of Science in 1824, vol. vii, p. 55. Dr. Webb gave it the name it bears, which is very descriptive of its remarkable action under the influence of heat. It occurs in small scales resembling green talc disseminated throughout a mealy magnesian mineral of an ash grey color, and resembling a decomposed talcose rock. The vermiculite occurs in small scales, rarely more than one-sixth of an inch in diameter, and having no well defined lateral crystalline edges; but still they are obviously imperfect crystals and probably hexagonal prisms. They split readily into thin laminæ, like talc, and are flexible, but not elastic. Hardness 1·; sp. gr. according to Mr. R. Crossley, 2·756, the mineral having been rendered dry previous to being weighed. Color dark olive green by reflected light, with a pearly and greasy lustre; by transmitted light, color apple green. Translucent, and sub-transparent in thin scales. Before the blowpipe a thin scale of the mineral suddenly exfoliates and swells into a cylinder or prism nearly *one hundred times its original length!* This exfoliation takes place at a temperature between 500° and 600° F., and not at a temperature of 300° F., hence it is not wholly due to interposition of water between the laminæ of the crystals.

In a glass tube closed at one end, on heating until exfoliation takes place, a certain portion of water is given off, but on raising the heat to redness a still larger quantity is obtained. This water restores the blue color to litmus paper, that had been reddened by acids, and is therefore slightly alkaline. The expansion of vermiculite by heat is so sudden and powerful as to burst a glass tube filled with it, producing an audible explosion and scattering the glass to a distance.

In the platina forceps a scale of the vermiculite melts readily into a yellowish green glass. With carbonate of soda it fuses to an opaque brown bead. With borax it dissolves readily, giving a yellow glass while hot, which becomes colorless when cold.

With salt of phosphorus, it dissolves giving a transparent glass, which is yellow while hot, and colorless when cold, and becomes somewhat milky white. It is decomposed by chlorohydric and sulphuric acids. Mr. Crossley used a mixture of these two acids in decomposing the mineral for separation of its ingredients; having previously ascertained that its decomposition by acids was complete.

Clean scales of the mineral were selected with great care by Mr. Crossley, who obtained the following results—

Silica, . . .	35·74	containing oxygen	=18·56	ratios =6·
Alumina, . .	16·42		7·66	2·
Protoxyd of iron, .	10·02		2·28	4·
Magnesia, . .	27·44		10·62	
Water, . . .	10·30		9·15	3·
	99·92			

Which gives approximately the following formula,*

$$2\dot{\mathrm{A}}\mathrm{l}\,\ddot{\mathrm{S}}\mathrm{i}+4\dot{\mathrm{M}}\mathrm{g}^3\,\ddot{\mathrm{S}}\mathrm{i}+9\dot{\mathrm{H}}$$

which is the formula given by von Kobell for *Pyrosclerite.*

Vermiculite therefore does not approach Pyrophyllite, which, according to the analysis of Hermann, gives the formula,

$$\dot{\mathrm{M}}\mathrm{g}^3\,\ddot{\mathrm{S}}\mathrm{i}^2+9\dot{\mathrm{A}}\mathrm{l}\,\ddot{\mathrm{S}}\mathrm{i}^2+9\dot{\mathrm{H}}$$

Mr. Crossley has devoted much time and attention to this analysis, and I am satisfied that it has been correctly made. The only subject for farther research is the cause of the very remarkable exfoliation of this mineral when exposed to heat. I ascertained the temperature at which the exfoliation takes place by heating the mineral on paper and on lead. It fully exfoliates below the fusing point of sheet lead, but not on a paper card, until it takes fire.

2. *On the Blowpipe characters of the Mineral from the Azores identified with Pyrrhite by J. E. Teschemacher;* by A. A. Hayes, (communicated.)—I received enough of the Pyrrhite from Mr. Teschemacher for the following trials. It proves to be a (columbate) niobate of zirconia, colored apparently by oxyds of iron, uranium and manganese. The following are its characters in the blowpipe flame. On the first impulse of heat, the assay becomes darker colored, its fine red color returning as the mineral cools; and this character may be observed, even after it has been highly heated for a long time. At the melting point of cast iron in the reducing flame, it becomes permanently darker and brown; on platinum wire, the assay dissolves in six bulks of fused borax and affords a clear colorless glass, which barely retains its transparency on cooling; becoming instantly opaline, or opaque by flaming. The oxydating flame causes opacity in a hot clear globule removed from the reducing flame. Phosphoric salt in the reducing flame affords a clear glass with one sixth its bulk, and when reduced, the glass is green. The oxydating flame colors the glass yellow. With one-fourth its bulk the fused salt dissolves the assay slowly, and the glass remains clear. In the reducing flame with twelve times its bulk of soda, the assay dissolves; some clear portions are seen while the globule is hot, but on cooling, opacity precedes the crystallization of the globule. When by continued reduction, the soda is partly evaporated, a gray brown slag remains, which cooled from the oxydating flame gives the green color, indicating oxyd of manganese.

* Considering $\dot{\mathrm{A}}\mathrm{l}$ and $\ddot{\mathrm{S}}\mathrm{i}$ as replacing one another, the analysis gives very exactly the formula $4\dot{\mathrm{M}}\mathrm{g}^3\,(\ddot{\mathrm{S}}\mathrm{i}, \dot{\mathrm{A}}\mathrm{l})^2+9\dot{\mathrm{H}}$.—J. D. D.

Decomposed by much soda and the resulting mass treated with nitric acid, a heavy white insoluble powder remains. Boiling water causes the heavy powder to take a flocculent form, which is retained. This powder exhibits with tests, all the characters of (columbic) niobic acid. The acid solution when mixed with carbonate of ammonia remains clear; heated, some iron oxyd falls, while a light yellow tint is retained by the fluid; oxalic acid causes the separation of a white earth, which, heated with sulphuric acid to destroy oxalic acid, dissolves, giving a fluid, forming with potash before complete neutralization, a white double salt, which has the characters of that from zirconia, but may contain oxyd of cerium also. The oxalate as first formed does not afford, when heated, the cinnamon brown color, characteristic of deutoxyd of cerium.

The extremely small portion of the mineral operated on forbids the expression of certainty respecting the bases, and although inclining to the opinion of the existence of cerium from the red color of the crystals, I am not in possession of any facts proving this point.

3. *On the Red Zinc Ore of New Jersey;* by A. A. Hayes, (communicated to one of the Editors.)—Some recent trials on the red oxyd of zinc, confirm my earlier statement that the manganese is in a protoxyd state, *mixed* with the oxyd of zinc. The object was however to separate the peroxyd of iron, so as to show that its power of coloring confers on the oxyd of zinc the blood red color seen in fine specimens. In the trials, that variety of scaly peroxyd of iron, *which is produced when chlorid of iron is decomposed by vapor of water*, was obtained, and this oxyd, *being transparent and blood-red*, gives, by being interleaved with the crusts of zinc sublimate, the red color: the evidence was conclusive.

4. *On the existing Mineral Localities of Lewis, Jefferson, and St. Lawrence counties, New York;* by Dr. F. B. Hough.—From the great number and variety of mineral species, which were discovered during the course of the State Geological Survey, in the northern part of New York, in addition to those that were known before, and have been discovered since, the mineral localities of that section have attained a merited notoriety, among amateur collectors, and scientific mineralogists.

Many of the localities have become exhausted, and others have been discovered, while there are yet others which have been attributed to these counties through mistake. A concise account of existing localities seems to be especially desirable.

Lewis County.—*Magnetic iron ore*, associated with sulphuret of iron, occurs in Greig; *bog iron ore*, in Watson, Diana, and New Bremen; *specular iron ore* in Diana, and *iron sand* on the sandy margins of most of the streams and lakes, throughout the primary regions in the county. *Calcareous tufa*, abounds in many of the springs that issue from the limestone formation; particularly in Lowville. *Tremolite* occurs frequently in *boulders* but not *in situ*, in the county. A mass weighing about a ton occurs a mile southeast of the village of Collinsville, in West Turin.

Wad occurs in the southwestern part of the town of Martinsburg, in nodules disseminated through the soil of a swamp. The masses are from one to three inches in diameter; pulverulent externally, but exhibiting a glossy fracture when broken. It soon crumbles on exposure.

In the town of Diana, the following minerals occur abundantly. *Tabular spar*, with *green coccolite*, *nuttallite*, *variegated serpentine*, *rensselaerite*, *black pyroxene*, *feldspar*, in crystals variously modified, and a singular mixture, apparently of graphite, chlorite, and specular iron ore, which has been strangely considered an "ore of silver." Associated with the foregoing, but in less quantities, are *sphene*, crystals of *sulphuret of iron*, and very rarely *zircon*.

The vicinity also affords surfaces spangled with minute crystals of *quartz*, upon a coarse variety of *agate*, and *calcedony:* and a *crystalline limestone* of a crumbling texture, and a sky-blue color.

Opake crystals of *quartz*, of large size, are frequent near the serpentine locality. Most of the localities in Diana, occur along the line of transition between the primary, and the sedimentary formations, and within two miles of the little village of Natural Bridge.*

The following localities attributed to Lewis county are exhausted, or the mining operations which produced them have been discontinued, so that specimens can be no longer procured. None of these mines will ever in any probability be reöpened.

Galena, occurred in the lead mines three-fourths of a mile N.W. of Martinsburgh village. It exhibited various forms, intermediate between the cube and octahedron. It occurred also arborescent, pseudomorphous, fibrous and massive. With it were associated *carbonate of lead*, *blende*, *sulphuret of iron*, *calcareous spar*, in the forms represented in the Mineralogical Report of the Geological Survey of New York, figures 60, 62, 71, 73, 74, 75, and 76, in which last form the sides of the prism were nearly obliterated by the approximation of the terminal planes;—also very rarely small cubes of *fluor spar*.

Near Lowville village, there formerly occurred *galena*, in minute crystals, associated with *sulphuret of iron*, *calcareous spar*, often beautifully crystallized, and magnificent specimens of *green fluor spar*, crystallized in small cubes of nearly uniform size, which were never modified by replacements upon their edges or solid angles.

Unfortunately this mineral was usually so penetrated by sulphuret of iron, as to be rapidly destroyed by the efflorescence of the latter. It may be possible to procure more of this mineral, but the expense would be great, and success very uncertain.

With the exception of an occasional boulder, containing *epidote*, *colophonite*, *tourmaline*, *garnet*, &c., the foregoing is a complete list of the minerals found in Lewis county. For a more particular account of the geological relations of these minerals, reference may be made to the "Am. Jour. of Agriculture and Science," Nos. xiii and xiv, pp. 267–314.

Jefferson County.—*Agaric mineral* abounds in the caverns of Watertown, and Pamelia.

Cacoxenite. Sterling iron mine, Antwerp.

Calcareous spar appears in numerous and peculiar forms of crystallization in the town of Antwerp, particularly in the vicinity of Oxbow village, and on the shores of Vroman and other lakes.

* Near the Natural Bridge, a few years ago, was opened a mine of *copper pyrites*, which occurred thinly disseminated through gneiss. It was unpromising, and after some outlay, operations were suspended. In one of the excavations were found traces of *coal*, much resembling anthracite.—S. W. J.

Saccharine limestone forms immense ledges in Antwerp, &c.

Theresa affords several localities of calcareous spar.

Calcareous tufa. Pamelia, Adams, &c., along the range of transition limestones.

Carbonate of iron crystallized at the Sterling iron mine, Antwerp.

Feldspar. In Alexandria, in great abundance. Antwerp, &c.

Fluor spar. Theresa, in several localities. The celebrated locality at Muscolongue lake, in this town, is nearly or quite exhausted. In Adams, associated with sulphate of barytes. It occurs here in delicate shades of pink and green.

Hornblende. Theresa. Alexandria.

Idocrase, in minute crystals, on the banks of Vroman's lake, in Antwerp near the village of Oxbow. It occurs in an impure limestone, with sphene, &c.

Iron, (*bog ore.*) Wilna, Antwerp, &c. In the latter town, it occurs in a deposit in which an immense variety of organic substances are mineralized by it. It is near the village of Oxbow.

Iron, (*specular ore.*) Theresa, Antwerp, and Philadelphia. It furnishes a vast amount of iron annually.

Mica, in Antwerp, near Vroman's lake crystallized in hexagonal prisms, often six inches in length.

Most "mineralogists" refer to Henderson, in this county, as a fine locality. After many inquiries I am forced to believe that none occurs in the town. This town as well as most of the adjoining ones, *is underlaid by transition limestone*, and no primary rock can occur in it, larger than *common bowlders.*

Pargasite. Antwerp, near Muscolongue lake.

Pyroxene, of a light color, near Vroman's lake, in Antwerp, associated with crystals of mica, and sphene.

Quartz. Antwerp and Theresa, associated with specular iron. Near Vroman, and other lakes, in the northern part of the county.

Scapolite. Rarely in slender crystals in Antwerp, on the farm of David Eggleson.

Serpentine. Theresa, Antwerp, of various shade of white and black. (Rensselaerite ?)

The *brecciated* or *porphyritic* variety, is a constant associate of specular iron, in Antwerp, Theresa, &c.

Sphene. In Antwerp near Vroman's lake.

Sulphate of barytes. Pillar Point, in Brownville, near Sackett's Harbor, near North Adams, in a vein which has been traced nearly a mile. A porous coralloid variety, occurs in Antwerp near the village of Oxbow. It is filled with vermicular cavities, and stained with iron.

Sulphate of strontia. Theresa, or Alexandria, in beautiful crystalline masses; of a snow-white color.

Sulphuret of copper and iron. In Antwerp, on banks of Vroman's lake.

Sulphuret of iron. Antwerp, associated with specular ores of iron.

Sulphuret of nickel. Sterling mine, Antwerp, in brilliant capillary crystals.

Tourmaline. In large crystals. Alexandria.

Tourmaline, (yellow.) Antwerp, in limited quantites.

Terenite, has been attributed to this county, (Antwerp,) but its locality is lost.

Tremolite, occurs in minute quantities, occasionally in cavities of Black river and Trenton limestone.

In addition to the foregoing the usual variety of minerals, occur scattered in detached bowlders, over the country.

St. Lawrence County.—The uncommon splendor and variety of minerals brought to light by the mania for mining speculations, which prevailed throughout the county about ten or twelve years since, has rendered St. Lawrence county proverbial for its mineral localities.

Most of these enterprises having proved unprofitable, and often ruinous, to those engaged in them, have been abandoned, and the iron mines are the only ones that are now wrought. No probability exists of any of them being ever resumed, and consequently many minerals formerly found here can be no longer procured at their localities. This applies especially to the *lead mines* of Rossie, which were discontinued about ten years since.

A vein of spar was often the only inducement to engaging in a mining operation, and many elegant specimens were obtained in these enterprises, which can no longer be procured. The following minerals occur at present in the county, being all of them more or less accessible, and abundant, with the exceptions specified.

Agaric mineral, in a calcareous spring, Governeur.

Apatite. Rossie, Hammond, &c. Good specimens readily procured with little labor and expense. A new locality was accidentally discovered in Rossie, about two miles from the village of Oxbow, in the fall of 1849.

Albite. Governeur, Fowler, &c., in granite.

Agate. A coarse variety in Fowler.

Arragonite. Iron mines, near Somerville.

Automolite has been attributed to Rossie. Its existence there is very doubtful. Locality unknown.

Babingtonite. Locality unknown. Said to occur in Governeur. After much search in the spot where it was said to occur, I am inclined to believe that if it was ever found there, it has become exhausted.

Blende. Morristown, DeKalb, Fowler, Macomb. Several of its localities are now inaccessible.

Calcareous spar. Governeur, Rossie, Russel, &c. The large limpid crystals from Rossie, are no longer procurable.

Calcareous tufa, frequently met with in calcareous springs.

Calcedony. Fowler.

Carbonate of iron. Iron mines, Rossie, magnificent specimens occasionally found; those of ordinary quality frequent.

Chondrodite. "Governeur near Somerville." This locality was a *boulder*, and has been carried off. Frequent in Rossie, near Yellow lake, in detached masses.

Dolomite. Hammond.

Feldspar. Rossie, Governeur, Hammond, &c.

Feldspar. Labradorite occurs near Ogdensburgh.

Fluor spar. Morristown, Governeur, associated with heavy spar.

Galena. No longer procurable at the localities without mining.

Graphite. Rossie, Governeur, Dekalb, &c.

Hematite. Iron mines, Rossie, Governeur, &c.

Hornblende. Dekalb, Rossie, Governeur, Potsdam, Pierrepont, &c.

Hyalite. Quartz, with the appearance of hyalite, is associated with apatite and zircon, in Hammond and Rossie.

Idocrase. Governeur.

Iron, (bog ore.) Hermon, Brasher, Fowler, Governeur, Canton, &c.

Iron, (magnetic.) Edwards, Russel, Pierrepont.

Iron, (specular.) Hermon, Rossie, Governeur, Edwards, Canton, Pierrepont and Fowler. Often beautifully crystallized and associated with interesting minerals. It is the most important iron ore in the county.

Mica. Governeur, near Somerville, in serpentine. Edwards, Macomb, Potsdam, Rossie, &c.

Pargasite. Rossie, Hammond, Russel, Hermon, &c.

Pearl spar. Banks of Oswegatchie in Rossie.

Pyroxene. Governeur, Rossie, Hermon, DeKalb, &c.

Quartz. Usually associated with specular iron ore. Rossie, Russel, Governeur; in Governeur the smoky variety occurs. In Russel the dodecahedron with triangular faces. Spongy quartz occurs in DeKalb.

Rutile, attributed to Governeur. No locality known in that town, or in the county.

Scapolite. Governeur, in great abundance, in primary limestone, associated with quartz, pargasite, and *formerly* with apatite. The latter mineral has become exhausted.

Satin spar. Rossie, Fowler, Pitcairn. In each of its localities it is associated with serpentine.

Serpentine. Governeur, near the tremolite locality. Edwards, Pitcairn, Rossie, DeKalb, Hermon, Fowler, Russel, Canton, Fine, Colton. In most of the above towns, serpentine occurs in ledges, and is associated with primitive limestone.

Rensselaerite, occurs in nearly all the above mentioned towns, it is of every shade of white, black, green, &c., and occurs crystallized, radiated, fibrous, laminated, and cleavable. The *brecciated* variety, is a constant associate of the specular iron ore, and in some localities, as at Kearney mine, near Somerville, it is beautifully variegated. The texture of this variety is so fragile, as to fall to pieces upon receiving a slight blow from a hammer. Varieties which have received the name of *soapstone*, and have been wrought into various ornamental articles, occur in Fowler, Edwards and Russel. It is often of a snowy whiteness, and passes by insensible gradations into talc, and tremolite.

Sphene. Rossie, in pale red and brown crystals, with apatite, pargasite and crystallized feldspar. Governeur, in black crystals, in granite.

Spinelle. Associated with mica, in serpentine, in the town of Governeur, near the village of Somerville. Crystals of a large size, (one and two inches on a side,) have been found here, but they are rare. Small brilliant crystals are common. The small crystals are very perfect, but the larger ones are much blended with the matrix. Color pink and reddish brown.

Sulphate of barytes. Governeur, in highly crystalline and fibrous varieties. Fowler, Rossie, DeKalb.

Sulphate of strontia formerly found in lead mines, Rossie. Locality inaccessible.

Sulphuret of iron. Rossie and Governeur, in iron mines. Fowler, Canton, &c.

Sulphuret of copper and iron. Canton, Fowler, Macomb, &c.

Tourmaline. Rossie, Governeur, Hermon, &c. Often of a brown and yellow color.

Tremolite. Governeur, in splendid crystalline and fibrous masses, associated with primary limestone, DeKalb. In Fowler, a purple variety occurs. Rossie, Hermon, Edwards, &c.

Zircon. Hammond and Rossie. Coarse opake specimens may be obtained with facility. Beautifully crystallized and very perfect specimens often procured. It occurs in primary limestone, associated with apatite, feldspar, loxoclase (?) hyalite, graphite, &c. The principal locality is on the farm of Mr. Hardy. It has been improperly attributed to the farm of Mr. Robinson.

5. *Isomorphism of Miargyrite and Augite.*—Miargyrite crystallizes in monoclinic forms, and the angles as given by Haidinger are M : M = 86° 4′, P : M = 101° 6′. Augite has M : M = 87° 6′, P : M = 100° 25′. The augite group of isomorphs with this addition includes, augite, pyroxene, glauber salt, acmite, hornblende and miargyrite.* Calculating the atomic volume of miargyrite we have

$$A = 3762{\cdot}8 \div 5{\cdot}234 \text{ (sp. gr.)} = 718{\cdot}9 \qquad C = 718{\cdot}9 \div 6 = 119{\cdot}8$$

The result 119·8 divided by $2\frac{1}{2}$, gives 47·92, which is very near the atomic volume of the augite series. If antimony is taken as a double atom, it gives $718{\cdot}9 \div 7 = 102{\cdot}7$, which is a little more than double the number for the augite series. Moreover, the whole number 718·9 is not much above the number for Hudsonite. We repeat the numbers here for comparison.

		A.	B.	C.	
Pyroxene,	1st var., $(\dot{C}a, \dot{M}g)^3\,\ddot{S}i^2$	637·	127·4	45·5	
	2nd var., $(\dot{C}a, \dot{M}g, \dot{F}e)^3\,\ddot{S}i^2$	645·2	129·	46·1	
	3d var., Hedenbergite,	673·4	134·7	48·1	
	4th var., $\dot{F}e^3\,\ddot{S}i^2$	674·7	135·	48·2	
	5th var., $\dot{M}n^3\,\ddot{S}i^2$	684·8	136·9	48·9	
	6th var., Hudsonite,	706·0	141·2	48·9	
Miargyrite,	- - - -	718·9		119·8 (or 102·7)	
Acmite,	- - - -	918·5	183·7	48·34	
Hornblende,	1st var. - -	971·6	138·8	48·58	
	2nd var., aluminous, -		155·95	47·25	
	3d var. " -		138·4	48·43	
	4th var. -		144·0	48·24	
Borax,	- - - -	1391·6	107·0	46·38	
Glauber salt,	- - -	1290·5	107·54	49·6	J. D. D.

6. *Analysis of the Schorlomite of Shepard;* by C. RAMMELSBERG, (Poggendorf's Annalen, lxxvii, 123, 1849).—Rammelsberg finds this mineral from Arkansas to consist of

	Silica.	Titanic acid.	Lime.	Protoxyd of iron.	Magnesia.	
1.	26·09	17·36	31·12	22·83	1·55 =	98·45
2.	27·85	15·32	32·01	23·75	1·52 =	100·45

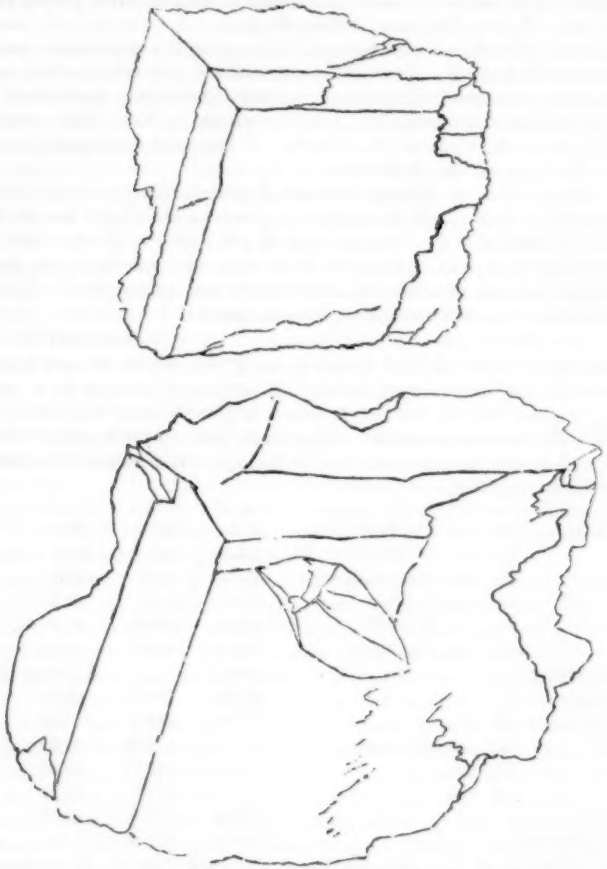
The results give the formula

$$2\dot{R}^3\,\ddot{S}i^2 + 3\dot{R}^2\,\ddot{T}i$$

In the 2nd analysis some titanic acid still remained with the silica.

* See pages 223, 228, 230, of this volume.

7. *Large crystals of Sphene.*—The accompanying figures of sphene are by Wm. S. Vaux of Philadelphia, from specimens in his cabinet, obtained at Diana, near Natural Bridge, Lewis Co., N. Y. The color is dark brown. The form is that of the so-called Lederite, which comes from the same locality; the narrow plane is the plane *n*, and the large one below to the right *y*.



8. *On the Ozarkite of Shepard;* by J. D. DANA.—The Ozarkite (this Journal [2], ii, p. 251), after an imperfect examination was pronounced by Prof. Shepard, as probably a silicious hydrate of lime and yttria, with possibly traces of thorina. It has since heen examined by J. D. Whitney, who obtained the blowpipe reactions of scolecite. Several specimens from Arkansas have been examined by Mr. G. J. Brush in the Yale Laboratory, New Haven, and found to consist largely of phosphate of lime. They have often the radiated appearance of a zeolite

with acicular crystallizations; but after Mr. Brush's discovery of phosphoric acid, the writer found by means of a glass that the acicular prisms were in fact hexagonal prisms of apatite. Other large prisms were also found in some specimens. The acicular mesotype-like mineral is associated with another of a mealy character and in part sub-lamellar, which may be a zeolite as observed by Whitney.

9. *The Lagoons of Tuscany*, (Bull. Soc. Geol. de France, Dec., 1848, 147.)—The Tuscan Lagoons are, properly speaking, natural depressions of the soil ordinarily filled with water from which hot vapors are ejected. They are situated within a space of ten or twelve miles, lying between 28° 27′ and 28° 40′ of longitude, and between 43° 10′ and 43° 15′ of latitude. The principal lagoons are those of Monte Cerboli, of Castel Nuovo in the valley of Cecina, those of Sasso, of Monte Rotondo, of the Lago del Edifizio, of Lustignano and of Serrazzano in the valley of Cornia. The ancients were acquainted with the Tuscan lagoons, and the name of Mount Cerberus accords well with the poetical and mythological ideas of the early people of Italy.

Even as late as the 18th century the lagoons were regarded only as a supernatural wonder which excited astonishment rather than courted investigation. Under the Grand Duke Leopold 1st, the chemist Hœfer discovered by analysis, that they contained boracic acid. This discovery, followed by farther explorations, has bestowed upon the lagoons an unrivalled industrial importance, and has brought into the countries possessing them an activity contrasting strikingly with the miserable state in which they before languished. It is a curious fact in their history that before the discovery of this acid, the fetid odor developed by the sulphuretted hydrogen gas,—the certain death which met the man who fell into the scalding baths,—the disruptions of the ground occasioned by the appearance of new *Soffioni*,—and above all the superstitious terror with regard to them, had made the people consider the lagoons as a scourge from which they sought deliverance by public prayers; but now if by any cause the *Fumacchi*, the source of common prosperity, should become extinguished, they would not fail to seek from heaven a restoration of this scourge, which in the skillful hands of M. Larderel, has become, to quote M. Bowring, a source perhaps of greater riches than the mines of Peru, or of Mexico, and certainly more reliable. After the discovery of Hœfer, Paul Mascagni, a noted chemist, had the first idea of procuring from the lagoons boracic acid like that of China, and of thus restoring to Europe the tribute that she had paid to Asia. But the attempt was not at first profitable, as the waters contain in solution at the moment of their escape from the earth, only an insignificant quantity of boracic acid. Another chemist having observed that a part of the acid was thrown beyond the lagoon, by the violence of the vapors, and that it was scattered on the margins of the craters, and moreover being confident that the waters were capable of dissolving a greater quantity of acid, endeavored to find means of saturating them by constructing upon the declivities of the country artificial lakes fed by the streams from the mountain. The vapors which issue from these lakes keep their waters constantly at a boiling temperature. After impregnation for twenty or thirty hours by the vapors of the highest lake, they draw off the waters into the second lake to

submit them to a new impregnation. From thence they are drawn into a third, and so on till they reach the receptacle at the lowest point. In their passage across six or eight lakes, they are charged with half per cent. of boracic acid. They are then led into the reservoir from which they are conducted into lead reservoirs for evaporation, to produce concentration; and to hasten that operation, the happy idea was proposed of substituting for the combustibles sometimes used, and which were enormously expensive, the direct application of the heat of the Soffioni. This improvement decided the success of the enterprise. It is surprising that it was introduced at so late a day, since this method was not new and had been long practiced at the solfatara of Pozzuoli in extracting alum from the earth that contains it. In the lagoons, the hot vapors for carrying on the evaporation are taken at their origin and carried across by lead pipes or by subterranean conduits below the boilers. Thus the fabrication is exceedingly simple, the locality itself furnishing the means of carrying it on. A single discharge of the vapors is sufficient to throw into ebullition, almost immediately, 20 or 30 cauldrons of a capacity of 20 barrels, which may be estimated at 84,000 pounds of liquid impregnated with boracic acid. Before allowing the vapors to escape, they direct them under the ovens in order to free the acid from its hygrometric moisture. Of late the somewhat complex system of boilers and coolers has been simplified by substituting rectangular tables of lead of 20 or 30 metres, divided at small intervals by transverse parallel divisions, but whose height is never raised above that of the edges. These tables have an inclination of two to three degrees. The water of the last lagoon is introduced upon the upper side, in small quantities. The hot vapors for evaporating are conducted in such a manner that they act upon the lower surface. The liquid after having filled the first compartment is diffused very gradually into the second, then into the third, and so successively to the last, where it reaches such a state of concentration that it deposits the crystallized acid; the workmen remove it immediately by means of wooden scrapers. This mode of gradual concentration is very ingenious, and requires so few hands that it may almost be said that the acid is obtained without expense. From 1818 to 1845 the quantity of acid manufactured was 33,349,097 Tuscan pounds. From 1839 to 1845 the mean quantity has been two millions and a half of pounds.

Thus in estimating the product at 7,500 pounds per day; the quantity of saturated water upon which they operate daily is 1,500,000 lbs. daily, and annually 547,500,000 lbs.

This labor brings to Tuscany 12 millions of pounds (10 millions of francs), and it is surprising that it should have remained unproductive during so many ages, and that it should have been reserved for the skill of M. Larderel, now Count of Monte Cerboli, and before 1818 a simple wandering merchant, entirely unacquainted with scientific researches, to discover the fugitive vapors and render them a source of inexhaustible wealth.

The violence with which the burning vapors escape gives rise to muddy explosions, when a lake has been drained by turning its waters into another lake. The mud is then thrown out, as solid matters are ejected from volcanos, and there forms in the bottom of the lake a crowd

of those little cones of eruption whose activity and play recall exactly under another form the *hornitos* of Malpays. Their temperature varies from 120° to 145° centigrade, and the clouds which they form above the lagoons constitute true natural barometers, whose greater or less density rarely disappoints the predictions that they announce.

While in an industrial point of view, the lagoons occupy the first rank among the natural products of Tuscany, they place new resources at the disposition of science, permitting the investigation of various geological phenomena, even under the direction of the will of the experimenter. The metamorphic gypsum which we have seen produced at Pereta under the influence of sulphuretted hydrogen vapors, is formed at the lagoons which, like those of *Monte Cerboli* and of *Castel Nuovo*, are made to cross argillaceous limestone beds; and with such abundance that their formation may be fully tested. Action also takes place at the same time upon the walls of fractures and the fissures of the soil which open a passage to the subterranean vapors. Thence it extends gradually into the interior of the masses, and it ends by gypsifying whole circles whose radius is generally that of the lagoons themselves. Pure limestones are converted into a lamellar sulphate of lime, but of a loose texture and free of cellules. This structure is probably due to the expansion they undergo from the addition of new materials, and perhaps also by the passage of the gas at the moment of the crystallization of the salt. The calcareous formations below the argillaceous, preserve after their transformation their primitive position, and they present an alternation of gypseous beds, and of argillaceous beds which the acid has freed from the soluble bases. When this influence is exerted in the direction of the thickness of the strata, it is very common to see towards the limits where the metamorphic influence ceases, a mass of rock strikingly calcareous at one of its extremities, terminating at the other extremity in a gypsum which the inhabitants use for buildings. The resemblance to the gypsum beds, occurring in the midst of the secondary formations, is exhibited even in the reddish tint with which oxydation marks the associate clays of the alberèse. But a peculiarity which has given me the solution of a problem which had embarrassed me thus far, deserves mention; for we have reproduced here certain phenomena of which the enormous deposits of the Provençal Alps present many examples. I had noticed at Roquevaire and at Digne, irregular argillaceous incrustations in which are found entangled without order, angular fragments of sulphate of lime of various sizes. In admitting the transformation of the jurassic limestone of these countries posterior to its consolidation under the influence of the acid vapors, it was difficult to explain the mode of formation of these breccias and the manner in which these fragments were introduced. In all these cases, they seemed to indicate an overflow of waters, but the theory opposes the intervention of waters for the accomplishment of the facts relative to the conversion of the limestone, or it leaves in doubt the part which they must have acted. But, observe what is apparent at the lagoons of Monte Cerboli and of Castel Nuovo. At the same time that the limestone is changed into gypsum, by the contact of sulphurous agents, the fragments of alberèse which waters had brought down from heights above to the midst of the miry and boiling

lakes, are thus changed into sulphate of lime and constitute, with the clays in which they sink, brecciated argillo-gypseous beds without stratification. That this fact should be equally apparent in the ancient beds under analogous circumstances, is at least what might be inferred from the examination of that which passes in the lagoons. We should also observe the analogous positions of the *boracite* of Luneburg, which is found in crystals disseminated in gypsum intercalated in the midst of a cretaceous bed, and the boracic acid and borates of the Tuscan lagoons.

These different facts well confirmed, establish in my view an intimate resemblance between the gypsum of the lagoons and the abnormal gypsum beds of secondary regions.

If the silicification of the Macigno which we have noticed in the neighborhood of the solfatara of Pereta should appear an exaggerated application of the theory brought forward, the verification of it may be traced in the lagoons of *Sasso* where the solution of the silex of the freestone and its redeposition are manifest in all places where circumstances allow of this double transformation. The Fumacchi of Sasso rise, to the south of the establishments, from beneath a vast mantle of fine grained freestone, over which passes the mountain road connecting the valley of the Cornia with the Province of Sienna. At intervals the road is interrupted by isolated boiling pools or shallow cavities, which exert a metamorphic action upon the region which they traverse. The first evidence of alteration is apparent in the color of the rock which from blackish gray becomes white. It is cracked in all directions. The vapors follow quickly these lines of separation, attack the silica of the macigno, dissolving it out, and immediately depositing it under a gelatinous form. The gelatinous mass becomes opaque in the air and assumes the resin-like appearance peculiar to hydrated silica. In connection with this we observe imbedded in a silicious cement, nuclei of a white micaceous sandstone unaltered at centre, causing a breccia appearance. This kind of breccia is finally, by the complete solution of the nuclei, converted into a grayish rock entirely silicious, which resounds under the hammer like clink-stone, and resembles exactly by its aspect and its roughness of touch, porcelain biscuit. Sometimes the solution is more rapid, and then the rock is formed of an agglutination of little grains analogous to those of an ancient quartz rock and possessing its tenacity and hardness. Examined with a glass, each grain is composed of an independent particle or driblet of hydrated silica, and they seem to have collected as viscous tears, such as would have adhered together in hardening. Breislak observed at the solfatara of Pozzuoli fragments of decomposed lava bound together by a silicious substance almost vitreous; but in the lagoon of Sasso the solution and permanent regeneration of silica effected at the expense of the macigno, are carried on upon a vast scale and over a space of great extent.

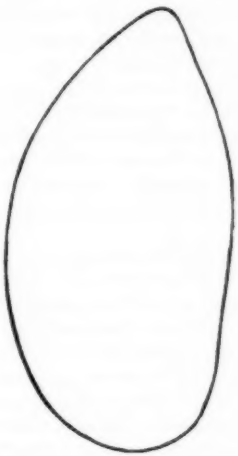
10. *On the Great Diamond in the possession of the Nizam;* by Henry Piddington, Curator, Museum Economic Geology.—At the November meeting of the Asiatic Society, Captain Fitzgerald, B.A., presented for the inspection of the Society a model in lead of this remarkable stone, and gave a brief note of its history, which will be found in my report for that month. He has since favored me with a more detailed one, which is as follows:—

Note by Captain Fitzgerald, Bengal Artillery, attached to the Nizam's Service, on the Nizam's Diamond—1*st December*, 1847.—"About twelve or fourteen years ago a large diamond was found in the Nizam's country under circumstances of rather a curious nature. The model now shown is the model of a part only, a piece having been chipped off, which, after passing through many hands, was purchased by a native banker for 70,000 rupees.

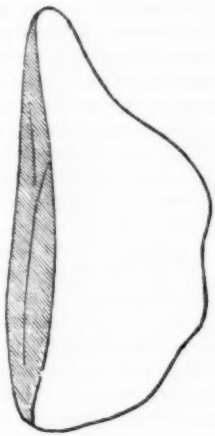
The larger piece, as represented by the model, is in the possession of his highness the Nizam, and at the time of discovery was exhibited to many European gentlemen.

The manner in which this diamond was originally found, may be considered interesting. It was first seen in the hands of a native child, who was playing with it, of course ignorant of its value. On *eight* annas being offered for what the poor people considered as a mere stone, their suspicion was excited, which led ultimately to the discovery of the bright stone being a real diamond.

Its form and size is shown below. This stone, hitherto unknown, may now be classed among the larger description of diamonds which we read of, but seldom see.



Base.



Side view.

The size of the stone exactly taken by callipers, from the leaden model, is as follows:—

	Inches.
Length,	2·48
Greatest breadth,	1·35
Average thickness,	0·92

I have had now exact models cast in glass from the leaden one exhibited at the meeting, and I find that

	Grains.
Their absolute weight is,	1164·50
Their specific gravity,	3·70

Now according to various authorities we have for the specific gravity of the diamond,

Ure,	3·53
Brewster, colorless,	3·52
orange,	3·55
Jameson, twelve authorities, mean,	3·52
Mean,	3·52

And hence assuming our model to be exact, (and it is very nearly so,) we have by a simple proportion not quite 1108 grains for the actual weight of the Nizam's diamond.

This is equal to 277 carats of weight of the rough diamond, and as the rough stones are usually taken to give but one half of their weight when cut and polished, it would allow 138½ carats, or a weight between the Pitt (or Regent) diamond (136¾ carats), and that of the Grand Duke of Tuscany (139 carats), for it in its present condition; and if we take it that one-eighth of what it would be when polished was taken off with the splinter sold to the native, as related by Captain Fitzgerald, we shall then have 155¾ carats for the possible weight of it, if it had been cut and polished entire; which would then place it as to weight between the Tuscan and the great Russian diamond of 195 carats, which last is well known to be an Indian stone.

We are not informed if this stone is considered likely to be one of pure water, which can only be ascertained by polishing it, though we know that the natives of India, and particularly of the Deccan, are too good judges of diamonds to mistake a topaz for one, and it is stated that 70,000 rupees have been paid for the fragment. It therefore certainly adds one extraordinary fact more to the history of this most wonderful of the gems."

11. *An account of the Strata and Organic Remains exposed in the Cuttings of the Railway from the Great Western line near Corsham, through Trowbridge to Westbury in Wiltshire;* by REGINALD NEVILLE MANTELL, Esq., Civil Engineer, (Proceedings of the Geological Society of London, Feb. 27, Sir C. Lyell, President, in the Chair.)—This line in the distance of fifteen miles passes through the usual series of the subdivisions of the oolite formation of that part of England. Numerous displacements of the strata occur, and in some parts thick beds of alluvial drift are superimposed on the regular deposits, and contain waterworn fragments of rocks and fossils from various formations. Near Westbury an extensive accumulation of bones of elephants and other large herbivorous mammalia was cut through; the quantity of these remains being so great, that they were employed to form an embankment. The immense number of fossil shells exposed in some of the areas, laid bare by the works, was surprising; the whole surface being thickly spread with Ammonites and other Cephalopoda, and osselets of Belemnoteuthis and Belemnites, mixed with shells of Rostellaria, Murex, Terebratula, Turritella, &c., deep sea and littoral mollusca being promiscuously intermingled. Some of the finest examples of Belemnites and Belemnoteuthis hitherto known, were found in these deposits, and have been described by Dr. G. A. Mantell [the author's

father] in the Philosophical Transactions. With these remains, were found teeth and bones of fishes and of four or five genera of reptiles. In the strata of Oxford clay lignite occurs abundantly, and in some places very large trunks and branches of coniferous trees, the wood retaining its structure and tenacity. The whole deposit resembled a mud-bank of a deep sea to which trees and other terrestrial plants, and littoral shells, had been drifted and mixed up with the relics of the mollusca of the profound depths of the ocean; constituting an interesting example of what M. Constant Prevost has aptly termed a fluvio-oceanic formation. The paper was illustrated by drawings and sections, and a splendid series of the fossils collected and arranged by the author: a table of all the genera and species by John Morris, Esq., was appended.

12. *Notice of the Remains of the Dinornis and other Birds, and of Fossil and Rock specimens recently collected by Walter Mantell, Esq., from the Middle Island of New Zealand;* by G. A. MANTELL, Esq., LL.D., F.R.S., &c., (Ibid.)—This memoir consisted, 1st, of a descriptive account of the country explored by Mr. Walter Mantell as Government Commissioner for the settlement of native claims on the east coast of the Middle Island, extending from northwest of Bank's Peninsula to Otago, a distance of about two hundred and sixty miles. 2dly, a general notice of the rocks, minerals and fossils; and 3dly, a summary of the facts brought to light in the course of the survey: forming the most interesting sketch hitherto made of the geology of that part of the colony. The rock specimens consisted of between 200 and 300 examples; principally of plutonic, metamorphic, and igneous substances. The foundation rocks of the country appear to be metamorphic schists, these are traversed by dykes of basalt, amygdaloids, &c. Obsidian, vesicular lava, and volcanic grits, in many places flank the sides of the great mountain chains which reach above the line of perpetual snow; and along the base of the range and over the adjacent plains are thick deposits of conglomerates and rich alluvial loam. Along the coast towards the south unaltered sedimentary strata appear. These belong to three distinct groups. The most ancient is the Ototara limestone which abounds in Terebratula, Echini, shark's teeth, &c., like certain European cretaceous beds; and the chief mass is composed of microscopic foraminiferous shells precisely similar to the white chalk of England; even the soft parts of the bodies of these minute animals are in many instances preserved. The deposit next in age is a blue upper tertiary clay full of marine shells of species still existing in the South Pacific Ocean.

Lastly, a ferruginous sandy grit with shells of recent marine species superimposed on the blue clay. Over the whole are spread, unconformably, layers of gravel and loam. Low hills of marly sand occur along the shores of the North Island, apparently a modern drift; this sand is wholly made up of the frustrules of Diatomacea. Of the fossil remains of birds the present collection contains above five hundred specimens referable to various species of Dinornis and allied genera; and to species of *albatross*, *penguin*, *water-hen*, *nestor*, *apteryx;* with portions of egg-shells of three different types. With the above were associated bones of a species of dog, and of two species of seal. The bones from the North Island, like those previously collected by Mr.

W. Mantell, and now in the British Museum, were from the titaniferous iron-sand near the mouth of the river Waingongoro. Those from *Waikouaiti* in the Middle Island, were imbedded in a morass of small extent, and which is exposed only at low water. This swamp is composed of vegetable fibres, sand and animal matter; it seems to have been originally a morass in which the *Phormium tenax*, or New Zealand flax, grew luxuriantly. The bones are literally tanned; and so well preserved as to appear as fresh as if recent. Among the specimens are crania and mandibles, and bones of the most colossal size. The most extraordinary relics are the entire series of bones (twenty-six in number) of the feet and shanks of the same individual Dinornis robustus, found standing erect, the one about a yard in advance of the other, as if the bird had been mired, and unable to extricate itself had perished on the spot. They were dug up and carefully numbered seriatim, and are now articulated like a recent skeleton. This is the only known instance of the bones of the foot and tarsus in natural connection, and consequently the first certain example of the structure of the feet of the colossal birds of New Zealand. There are no clear indications of this bird having had a hinder toe, as in the smaller species of Palapteryx in which the articulation for a posterior toe is strongly marked. The foot when recent must have been sixteen inches long and eighteen inches wide; the height of the bird to which they belonged, was about ten feet. The author in a highly interesting summary, suggests that these bone deposits, though geologically modern, are of high antiquity in relation to the human inhabitants of New Zealand; and considers it probable that these stupendous birds formerly ranged over a vast continent, now submerged, and of which the islands of the Pacific are the culminating points. Although there seems little doubt that like the Dodo and Solitaire of the Mauritius, and the gigantic elk of Ireland, the last of the Moas was exterminated by human agency, yet it is probable that a change in physical conditions, had prepared for their final annihilation. Of the organic law which determines the extinction of a race of highly organized beings, and whose effects through innumerable ages palæontology has in part disclosed, we are as utterly ignorant as of that which governs the first appearance of the minutest living organisms the powers of the microscope enable us to descry: both are veiled in inscrutable mystery; the results only are within the scope of our finite comprehension.

III. Zoology.

1. *Supplementary Observations on the Structure of the Belemnite and Belemnoteuthis;* by Gideon Algernon Mantell, Esq., LL.D., F.R.S., Vice President of the Geological Society, &c.—(Proc. Royal Society, February 14, 1850.)—In this communication the author describes his recent investigations on the structure of the two genera of fossil Cephalopoda, whose remains occur so abundantly in the Oxford clay of Wiltshire, namely, the Belemnite and Belemnoteuthis, as supplementary to his memoir on the same subject, published in the Phil. Trans., 1848. In that paper evidence was adduced to show the correctness of the opinion of the late Mr. Channing Pierce, as to the generic distinction of these two extinct forms of Cephalopoda.

As however several eminent naturalists have expressed doubts as to some of the opinions advanced by the author in his former memoir, figures and descriptions are given in the present notice, of beautiful and instructive specimens lately discovered in Wiltshire, and which he conceives establish his previous conclusions. Dr. Mantell states as the result of his examination of several hundred examples, that our actual knowledge of the organization of the animal of the Belemnite is at present limited to the following parts, viz.—

(1.) An external *Capsule* or *periostricum* which invested the osselet or sepiostaire, and extending upwards, constituted the external sheath of the receptacle.

(2.) The *Osselet*, characterized by its fibrous radiated structure, terminating distally in a solid rostrum or guard, having an alveolus, or conical hollow, to receive the apical portion of the chambered phragmocone; and expanding proximally, into a thin cup, which became confluent with the capsule, and formed the receptacle for the viscera.

(3.) The *Phragmocone*, or chambered, siphunculated, internal shell; the apex of which occupied the alveolus of the guard, and the upper part constituted a capacious chamber, from the basilar margin of which proceeded two long, flat, testaceous processes. These structures comprise all that are at present known of the animal to which the fossil commonly called "*The Belemnite*," belonged.

Of the *Belemnoteuthis* (the fossil cephalopod which Prof. Owen regards as identical with the Belemnite) many examples of the body with eight uncinated arms, and a pair of long tentacula, having an ink-bag and pallial fins, have been discovered. The osselet of this animal, like that of the Belemnite, *has a fibro-radiated structure*, investing a conical chambered shell; this organ, for reasons fully detailed in the memoir, the author affirms could never have been contained within the alveolus of a Belemnite; the soft parts of the animal of the Belemnite are therefore wholly unknown.

Many beautiful specimens of Belemnites and Belemnoteuthis were exhibited by Dr. Mantell to the Society, in proof of the statements contained in the memoir.

2. *On the Pelorosaurus; an undescribed gigantic terrestrial reptile, whose remains are associated with those of the Iguanodon and other Saurians, in the Strata of Tilgate Forest;* by Gideon Algernon Mantell, Esq., LL.D., F.R.S., Vice President of the Geological Society, &c. (lb.)—The author had for a long while entertained the idea, that among the remains of colossal reptiles obtained from the Wealden strata, there were indications of several genera of terrestrial saurians, besides those established by himself and other geologists. The recent discovery of an enormous arm-bone, or humerus, of an undescribed reptile of the crocodilian type, in a quarry of Tilgate Forest in Sussex, where Dr. Mantell had many years since collected numerous teeth and bones of the Iguanodon, Hylæosaurus, &c., and some remarkable vertebræ not referable to known genera, induced him to embody in the present communication the facts which his late researches have brought to light.

The humerus above mentioned was found imbedded in sandstone, by Mr. Peter Fuller of Lewes, at about twenty feet below the surface; it presents the usual mineralized condition of the fossil bones from the

arenaceous strata of the Wealden. It is four and a half feet in length, and the circumference of its distal extremity is thirty-two inches! It has a medullary cavity three inches in diameter, which at once separates it from the Cetiosaurus and other supposed marine saurians, while its form and proportions distinguish it from the humerus of the Iguanodon, Hylæosaurus, Megalosaurus. It approaches most nearly to the Crocodilians, but possesses characters distinct from any known fossil genus. Its internal structure is beautifully preserved, the Haversian canals and bone-cells being as distinct as in recent bones. Its size is stupendous, far exceeding that of the corresponding bone even of the gigantic Iguanodon; the name of *Pelorosaurus* (from πέλωρ, monster) is therefore proposed for the genus, with the specific term *Conybeari*, in honor of the palæontological labors of the present Dean of Llandaff, the Rev. W. D. Conybeare.

No bones have been found in such contiguity with this humerus, as to render it certain that they belonged to the same gigantic reptile; but several very large caudal verterbræ of peculiar characters, collected from the same quarry, are probably referable to the Pelorosaurus; these, together with some distal caudals of the same type, are figured and described by the author.

Certain femora and other bones from the oolite of Oxfordshire, in the collection of the Dean of Westminster at Oxford, are mentioned as possessing characters more allied to those of the Pelorosaurus, or to some unknown terrestrial saurian, than to the Cetiosaurus, with which they have been confounded.

As to the magnitude of the animal to which the humerus belonged, Dr. Mantell, while disclaiming the idea of arriving at any certain conclusions from a single bone, stated that in a Gavial eighteen feet long, the humerus is one foot in length; *i. e.* one-eighteenth part of the length of the animal, from the end of the muzzle to the tip of the tail. According to these admeasurements the *Pelorosaurus* would be eighty-one feet long, and its body twenty feet in circumference. Even if we assumed the length and probable number of the vertebræ as the scale, although we should have a reptile of relatively abbreviated proportions, yet in this case, the original creature would surpass in magnitude the most collossal of reptilian forms.

In conclusion, Dr. Mantell comments on the probable physical conditions of the countries inhabited by the terrestrial reptiles of the secondary ages of geology. The highly organized land saurians appear to have occupied the same position in those ancient faunas, as the large mammalia in those of modern times. The trees and plants whose remains are associated with the fossil bones, manifest, by their close affinity to living types, that the islands or continents on which they grew, possessed as pure an atmosphere, as high a temperature, and as unclouded skies, as those of our tropical climes. There are therefore no legitimate grounds for the hypothesis in which some physiologists have indulged, that during the "*Age of Reptiles*" the earth was in the state of a half-finished planet, and its atmosphere too heavy, from an excess of carbon, for the respiration of warm-blooded animals. Such an opinion can only have originated from a partial view of all the phenomena which these problems embrace; for there is as great a discrepancy be-

tween the existing faunas of different readings, as in the extinct groups of animals and plants which geological researches have revealed. The memoir was illustrated by numerous drawings, and the gigantic humerus of the Pelorosaurus and other bones were placed before the Society.

3. *On Entophytes;* by Dr. LEIDY, (Proc. Acad. Nat. Sci., Philad., Feb., 1850, v, p. 8.)—Dr Leidy presented to the examination of the Society a colored and several other drawings of what he termed an entophytic forest, taken from a portion of the mucous membrane of the ventriculus of Passalus cornutus. He remarked that at least six species of entophyta were found growing upon the mucous membrane of the ventriculus of P. cornutus, which were often present in great quantity, frequently some thousands, and which from their number, polymorphous appearance of several species, and attachment to various appendages of the mucous membrane, resembled very strikingly a miniature Brazilian forest, which was heightened in some degree by the existence of a nematoid worm, which recalled to mind the idea of one of the serpents of such a forest.

A somewhat similar drawing he exhibited, taken from the small intestine of Julus marginatus.

Other drawings were also presented. Dr. L. stated that among his collection of Julides, he had a number of times observed individuals to become dull in color, and almost motionless, which phenomena were followed by the death of the animal. It occurred to him that, in such a state, there might be exhibited some change in the character of its entophyta, as usually found in the active condition of the animal. Upon removing the intestine of an individual which had just died, he noticed that the entozoa which usually occupied the small intestine, had passed into the rectum, and upon the surface of the mucous membrane of the former, was developed a new plant. This is an oblate spheroidal body, white in color, translucent, embossed upon the surface, and presenting, when viewed by transmitted light, some resemblance to a minute bleached shell of an Echinus; by reflected light, it resembled a minute, white Lycoperdon. This plant was strewed all over the mucous membrane, but grew in greatest quantity along the course of filaments of Enterobrus, which appeared attached to the mucous membrane throughout their length by it. When compressed it opened, and spread into several leaf-like segments, and exuded a clear fluid with faint granules. He thought that probably this plant might be another stage in the existence of Enterobrus, for in the large number of individuals of Julus which he had examined, upward of 130, although he had observed the development of Enterobrus from spore-like bodies, even to the formation of what he supposed to be the sporangia, yet he had never been able to detect the formation of spores, and when he saw this new plant enveloping the Enterobrus filaments, he suspected that there might be a phenomenon here presented analogous to the alternation of generation in certain animals, but had not yet satified himself that such was the case.

He also stated that he had discovered a fourth species of Enterobrus in Polydesmus virginiensis, and another entophyte analogous to Enterobrus growing in Polydesmus granulatus. The latter differs from Enterobrus in having numerous globular cells at the free extremity of the

principal cell. He adverted to the several theories of cell formation, and said that in the last mentioned plant, in the development of the globular terminal cells, the division of the permanent cell wall followed the division of the cell contents. In conclusion, he observed, that these matters would be more fully treated of hereafter, in a memoir which he was preparing on the subject.

4. *On Infusoria on the Teeth;* by Dr. H. I. Bowditch, (Proc. Amer. Acad. of Arts and Sciences, Boston, Dec., 1849, p. 183.)—Dr. H. I. Bowditch gave the result of the microscopic examination of the accumulations on the teeth of healthy persons, near the gums, in forty-nine individuals, most of whom were very particular in their care of the teeth. Animalcules and vegetable products were found in every instance except two. In those cases the brush was used three times a day, and a thread was passed between the teeth daily. Windsor soap was also used by one of these two persons, with the brush. Dr. Bowditch had tried the effects of various substances in destroying the animalcules, and especially of tobacco, by which they seemed to be in no wise incommoded. Soap-suds and the chlorine tooth-wash invariably destroy them.

IV. Astronomy.

1. *New Comet.*—(Jour. of Com.)—Rev. Mr. Jenkins, of Georgetown College, writes that on his way to Rio Janeiro, Nov. 28, 1849, he saw distinctly a comet to westward, nearly in the track of the sun, and about 14 degrees above the horizon (hour not mentioned); the nucleus being very distinct, and about as large in appearance as Mars, the tail curved and pointing southward, quite bright and nearly a degree in length, as seen by the naked eye.

2. *Expected return of the great Comet of* 1556.—This comet is generally supposed to be identical with that of 1264, and if so, its period must be about 292 years. Leaving out of view any consideration of the effect of planetary action, the return of this comet might have been expected at any time since February, 1848. Although watch has been constantly kept since that period, the comet has not been detected. But its return is not yet to be despaired of. Mr. J. R. Hind, of London, states in a letter to the Editor of the *London Times*, dated March 7, 1850, that Mr. J. T. Barber of Etwell, has computed the effect of the perturbations due chiefly to Jupiter's attraction during the last revolution. Mr. B. finds that "between the years 1556 and 1592, the united attraction of Jupiter and Saturn would diminish the period 263 days, but that between 1592 and 1806, it would be increased by the action of Jupiter alone no less than 751 days, so that a retardation of 488 days must take place. How much longer Saturn, Uranus and Neptune may detain it beyond this time, we do not at present know." Mr. Hind considers it important that search for the comet should be continued until the close of 1851, and that on the supposition that it is within four or five months of its return to perihelion, the region of the heavens about the constellation Hydra should at this time be particularly examined.

V. Miscellaneous Intelligence.

1. *On the Gradual Production of Luminous Impressions on the Eye, and other phenomena of Vision;* by William Swan, F.R.S.E. (Proc. Roy. Soc. Edinb., 1849, ii, 230.)—The object of this communication was to ascertain the relation between the apparent brightness of a light, and the time during which it acts on the eye. In order to examine the intensity of luminous impressions of short duration, the author made use of discs, having sectors of known angles cut out of their circumferences, which were made to revolve at known velocities between the eye and a luminous object. In this manner, the object is seen at each revolution of the disc for a short interval of time, of which the duration is easily ascertained. An instrument termed a Selaometer (from σελας, *brightness*), to indicate its use as a measure of the intensity of luminous impressions, was devised for the purpose of comparing the brightness of the flashes caused by the revolution of the disc, with a light of known intensity. This instrument consists of two screens, placed so as to face each other, having each a circular aperture of the same diameter, to which is fitted a piece of obscured glass. A disc, having a sector of a known angle, revolves in fornt of one of these screens, so that the aperture in it is visible at each revolution of the disc throughout the sector. The apertures are illuminated by gas flames behind them, which admit of having their distances from the screens varied, so as to increase or diminish the illumination of the apertures. A rectangular prism of glass is placed half way between the apertures, with its faces inclined at angles of 45° to the line joining their centres; so that they are seen in apparent contact by reflection from the faces of the prism, and their relative brightness can thus be compared with great nicety. The light behind the revolving disc is kept at a constant distance from the screen during an experiment; and, before causing the disc to revolve, the apertures are made equally bright by varying the distance of the other light from its screen. When the disc is put in motion, the apparent brightness of the aperture behind it is instantly diminished; and the equality of the apparent brightness of the apertures in the screens is restored, by increasing the distance of the light from the other screen. The ratio of the brightness of the impression produced by the light during the revolution of the disc, to the brightness of its impression, when seen by uninterrupted vision, is that of the squares of the distances of the other light from the aperture in its screen.

The following are the principal results obtained by means of this apparatus:—

(1.) When the eye receives, from a light of common intensity, a succession of flashes of equal duration, which succeed each other so rapidly as to produce a uniform impression, this impression will also have a constant intensity, provided the number of flashes in a given time varies inversely with the duration of each flash.

(2.) The brightness of the impression produced by flashes of light of a given intensity, which succeed each other so rapidly as to produce a uniform impression on the eye, is proportional to the number of flashes in a given time.

(3.) When light of a given intensity acts on the eye for a short space of time, the brightness of the luminous impression on the retina is exactly proportional to the time during which the light continues to act. This law has been proved to be true for impressions lasting from $\frac{1}{18432}$ to $\frac{1}{24}$ of a second. The intensity of the impression produced by light which acts on the eye for $\frac{1}{100}$ of a second, is almost exactly $\frac{1}{10}$ of the brightness of the light when seen by uninterrupted vision; and it is also ascertained that light requires about the tenth part of a second to produce its full effect on the eye.

(4.) It is found that lights of different intensity act on the eye with equal rapidity, so that even the light of the sun produces an impression with no greater rapidity than that of a common gas flame.

(5.) Rays of different refrangibility act on the eye with equal rapidity.

(6.) Since Professor Wheatstone's experiments have proved that the light of the electric spark of high tension continues for less than the millionth part of a second, and it has been shewn that the brightness of the impression, produced by light on the eye, increases in the arithmetical proportion of the time during which it continues to act on the retina, it follows that the apparent brightness of the electric spark is only $\frac{1}{1000000}$ of what it would become if the duration of the spark could be prolonged to $\frac{1}{10}$th of a second. From the great apparent brilliancy of the nearly instantaneous electric spark of high tension, when compared with the sensibly continuous light of Voltaic electricity, it is inferred that the brightness of electrical light increases with the tension of the electricity.

2. *Foster's Geological Chart.*—The following announcement has been received for publication in this Journal. It affords us pleasure to know that the Chart alluded to has not the sanction of Prof. Mather's name.

JACKSON C. H., Ohio, March 28th, 1850.

To the Editors of the American Journal of Science.

GENTLEMEN,—I received a few days since the March No. of the Am. Jour. of Science, in which is a notice of Foster's Geological Chart, (vide p. 309, vol ix, new series,) saying "A revised copy, as now ready for publication, having the signatures of Professors E. Emmons and W. W. Mather, has been shown us by the author."

My name on that Chart is a forgery. I have never seen the Chart, have never authorized my name to be put on it, and pronounce the attempt to palm off that production under my signature or recommendation, a base imposition on the public, and a still baser imposition on me.

[Signed] W. W. MATHER.

3. *Lefroy on the Application of Photography to the Self-registration of Magnetical and Meteorological Instruments*, (see page 319.)—Mr. Lefroy has sent us the following account of his method of treating his mirrors when tarnished.—The mirror will probably be found in course of time, to get tarnished and to require cleaning, this may be done with soft leather, from which all the dust has been beaten out, and which has been well washed in soap and water, and dried before use. If a turning lathe is at hand, a convex buff, fitting the mirror, and well covered with two or three thicknesses of leather, may be centered on it, and the mirror held against it in a support of some kind, while it is made to revolve, but

the least application of polishing powders, however fine, will endanger an alteration in the form of the mirror, and destroy the sharpness of the focus capable of being produced by it. The greatest care must be taken to keep the leather clean and dry.

4. *On the Cause of the Diurnal Variations of the Magnetic Needle;* by W. H. Barlow, Esq., M.I.C.E.—(Phil. Mag., [3], xxxiv, 344, from a letter addressed by Mr. Barlow to the Editors of the Phil. Mag.)—In the number of your Journal for April, an extract from a letter from M. de la Rive to M. Arago is published, in which the author attributes the diurnal variations of the magnetic needle and the auroræ boreales to the effect of electric currents at the surface of the earth and in the atmosphere.

In the confirmation of this theory mention is made of a remarkable effect observed by M. Matteucci in the apparatus of the electric telegraph between Ravenna and Pisa during the magnificent aurora on the 17th of last November; and the author concludes by observing that "it would be highly interesting and important to profit by those telegraph wires, which are found to have a direction more or less approaching to that of the declination needle, in order to make with them, when they are not in use for ordinary purposes, some observations which would enable us to demonstrate and to measure the electric currents which probably traverse them."

My object in addressing you is to state, that in the early part of 1847, I was led to undertake extensive observations on this subject, in consequence of the peculiar disturbances occasionally visible on the telegraph instruments of the Midland Railway (on which line the telegraph was erected under my superintendence as the company's engineer).

These disturbances were at first attributed to atmospheric electricity passing to the earth by means of the wires; but from certain effects observed, I was led to infer that they were due to other causes; and in order to explain these effects, it is necessary to state that the Midland system of telegraphs consists of four principal lines centering in Derby, as follows:—

1st. From Derby northwards to Leeds.
2nd. From Derby northeast to Lincoln.
3rd. From Derby southwards to Rugby.
4th. From Derby southwest to Birmingham.

The disturbances on these four telegraphs were observed to occur simultaneously, with rare exceptions; and the direction of the current in the two telegraphs proceeding northerly and northeasterly was always contrary to those proceeding southerly and southwesterly; that is to say, when the deflection was such as to indicate that the current was towards Derby on the first two, it was from Derby on the last two; and when it changed in one, it changed in all. It was also observed that on the 19th of March 1847, there was an unusual degree of disturbance during the presence of auroræ boreales.

As these effects could not be attributed to the transit of ordinary atmospheric electricity along the wires to the earth, I determined to make a set of experiments on the subject.

Having obtained delicate galvanometers, I first ascertained that currents are at all times perceptible in the telegraph wires to a greater or

less extent when the galvanometer is applied on a sufficient length of wire, and between two earth connections; but that wires having no earth connection, or only one, exhibited no currents.

I also found by simultaneous observations on two galvanometers, applied one at each extremity of a wire forty-one miles long, that the changes of force and direction of the currents were simultaneous at both ends; the current passing direct from one earth connection to the other.

But the most interesting fact which appeared during these observations, and that which bears immediately on the remarks contained in the letter of M. de la Rive, is that there is a daily movement of the galvanometer needle, similar to that of the horizontal magnetic needle, produced by the electric currents travelling in one direction from about 8 A. M. to 8 P. M., and returning in the opposite direction during the remainder of the twenty-four hours. The times of zero are not regularly maintained and vary from 7 to 10 o'clock both in the morning and evening; but the greatest regularity is observable in the morning, and the mean result of numerous observations is as above stated.

This regular diurnal movement of the galvanometer needle is subject to disturbances of greater or less force and duration, which are found to be of greatest energy during magnetic storms, and when an aurora is visible; and in these cases the currents are so strong as to affect the ordinary telegraph instruments, and sometimes prevent altogether the transmission of messages.

The next experiments were made with a view to ascertain the direction in which these currents alternate; and the result, as determined from numerous observations, denotes it to be from northeast to southwest. The nearer this line is approached, the more decided is the effect on the galvanometer; but between east and south, and between north and west, the effect is smaller; and in approaching northwest and southeast, it becomes indefinite and irregular, but never ceases entirely.

It also appeared that the effect depended, not on the direction of the wire itself, but on the relative directions of the two earth connections; that is, the points where the wire was connected with the earth. I next made simultaneous observations with the galvanometers and a declinometer needle; from which it appeared, taking the mean of numerous observations, that that part of the day in which the currents flow southwards (that is, from 8 or 9 A. M. until the evening), the variation of the declinometer needle is westerly; and that during the night and early part of the morning (at which time the currents travel northwards) the variation is easterly; also, that the large disturbances called magnetic storms are simultaneous on both instruments.

But although there is this resemblance in the general features of the movements of both needles, the paths described are not similar. The movements of the galvanometer needle are more frequent and rapid than the declinometer, and the deflection frequently changes over from right to left without a corresponding movement of the declinometer.

The observations thus briefly recorded formed the subject of a paper which was read at the Royal Society on the 17th of June, 1847; and I have thought it desirable to make this communication to your Journal on reading M. de la Rive's letter, because it rather curiously happens, that the unusual delay which has arisen in the publication of my paper

by the Royal Society is attributable to the fact, that I arrived from these experiments at the same conclusion as M. de la Rive, as to the electric origin of the diurnal variation of the magnetic needle, which I considered to be the effect of the alternating electric currents exhibited by the telegraph wires.

The Royal Society were unwilling to give their sanction to this view of the case, and only consented to the publication of the observations above described on my omitting that portion of the paper.

The paper is, however, now in the hands of the printers, and will I hope, be shortly before the public.

I ought to state in conclusion, that my idea of the origin of the currents differs in one respect from the theory of M. de la Rive; inasmuch as he considers them to rise in the atmosphere, whereas I have attributed them to thermo-electric action in the crust of the earth. I speak of course with great deference on a subject of this kind; but there is an important fact tending to this conclusion which is now well ascertained, namely, that in the telegraphs which are laid entirely under ground, deflections occur similar to those before described; while wires suspended in the air exhibit no deflections, unless they are connected with the earth in two places, and then the direction in which the current travels depends on the relative positions of the earth connections, however circuitous may be the route of the wire itself.

Derby, April 12, 1849.

5. *The Ruins of Nineveh*, (London Lit. Gaz., March 9, 1850, from The Times).—A correspondent has favored us with the subjoined extracts from the letter of Mr. Stewart Erskine Rolland, late of the 69th Regiment, who is now at Nimroud with Captain Layard, assisting him in his endeavors to bring to light the hidden antiquarian treasures of Nineveh. The difficulties which the gallant and enterprising discoverer has to contend with, owing to the limited pecuniary resources at his disposal, are dwelt on by our correspondent, who fears that the French antiquarian agent recently despatched will, with his much larger funds (30,000*l.* it is stated), materially encroach on the harvest of antiquities which would fall to the lot of the English nation, were Capt. Layard's exertions backed by more ample means:—

"The first two or three days at Mossul I spent in examining the excavations of Koyunjik, where fresh slabs are being every day brought to light. Two new colossal bulls and two colossal figures were discovered while I was there, at the entrance of the city gates; and the pavement at the gateway, marked with ruts by the chariot wheels, was also uncovered. I left my wife under Mrs. Rassam's care, and accompanied Layard a day's journey to the villages of Baarshekah and Bamyaneh, and to the mound of Khorsabad. We took greyhounds with us and had a day's hunting, catching seven antelopes. After our return, Mr. Layard, Charlotte, and I, and our servants, embarked on a raft, and floated down the Tigris in seven hours to this little village of Nimroud, close to a large mound, which was the first excavated, sending our baggage and horses by land. We have since been residing in his house here; it is, in fact, little more than a mud hut; but he has put in glass windows, a table, and some sofas, and made it as comfortable as circumstances will admit. Layard has placed a party of the workmen under my control, and allowed me to dig where I please. I am sinking

wells in all directions, and am not without hopes of discovering subterranean chambers, which I am convinced must exist. In one place considerably below the level of any of the hitherto discovered monuments, a brick arch between two walls of brick has been uncovered: it is a puzzle to us all. Another great discovery is an immense stone wall of most solid masonry inside the brick pyramid. The workmen are laboring to force an entrance into it; but their progress is necessarily very slow, not exceeding a foot or two in a day. But the greatest discovery yet made since the earth was first turned remains to be told. I will give it you in due order.

"*January* 3, 1850.—On the 28th of December, Layard and I, with our attendants and two or three Arab Sheikhs, started off to pay a visit to the 'Tai,' on the other side of the 'Zab.' We were the first Europeans who had ever visited that country. Three hours' galloping from Nimroud brought us to the banks of the stream, which is as rapid and broad as the Tigris, and nearly as deep, but here, being divided into four branches, is fordable. With some difficulty we swam our horses across it, getting of course very wet in the operation. Our visit here has a threefold object—first, to explore the mound of Abou Sheeta, which appears to contain a buried city; secondly, to make friends between two rival chiefs of the Tai; and, thirdly, to promote a reconciliation between them and their implacable enemies, the Jibours, which will much facilitate Layard's future operations. Our first visit was to the camp of the Hawar, who is considered by all the Arabs, even by those of the great African desert, to be the highest born and noblest among them. He is probably the man of most ancient descent in the world, reckoning his genealogy far above the time of Abraham. He is supported in his pretensions to the chieftainship by the noblest of the tribe, while his rival, Feras, is supported by the Turks and the greater number of the Tai. His brother, the handsomest man I have ever seen, came out to meet us with 100 horsemen, most of whom had come to our village to plunder the other day. They galloped madly about the plain, brandishing their long spears, shouting their war cry, and escorted us in great state to the camp of the Sheikh, where he stood to receive us. I never saw so noble or dignified a figure; he is eminently handsome, though advanced in years and suffering from ill-health. In stature he is gigantic—six feet four or five at least, and erect as a pine tree. His tent was a spacious one, a load for three camels, with the women's tents on one side and that of the horses on the other, all under the same covering. Mats and cushions were spread on the floor of the tent, on which the Hawar, Layard and I sat, as did his brother, his uncle, and others of the magnates of the tribe, while the rest stood in a semicircle at the door. A noble hunting hawk stood on his perch in the centre. We partook of spiced coffee, discussed the business on which we came, and dined in the tent on a capital stew of mutton, pumpkins, rice, and sour milk. After we had partaken, the rest of the tribe made their repast, a certain number sitting down together, each man rising when he was satisfied, and a sort of master of the ceremonies calling out the name of the man who was to succeed him. There was no bustle or indecorum. After dinner they all said their prayers. We had set on our tents, which, by the way, got very wet in crossing the river, and we pitched them close to that of the Sheikh. The next

day the encampment changed its quarters. I have seldom seen a more picturesque sight. The Sheikh's tent was struck first, and the long procession of laden camels, horsemen, donkeys, and cattle, stretched as far as the eye could reach. I calculated that there were about 2,000 persons with their camels, horses, and cattle. We paid our visit to Feras, the rival Sheikh, taking with us the brother of Hawar. We were well received, though not with the same dignified courtesy. While we were away the workmen had opened a trench, by Layard's direction, to show my wife a certain slab which he had buried; in doing so they uncovered three copper cauldrons of immense size, and some huge dishes of metal. Layard carefully removed the earth from one cauldron, which was partially filled with it, and discovered an immense variety of ivory ornaments, an iron axe-head, and innumerable other articles, which for the present I must forbear to mention, having promised secrecy. Layard removed as many as he could, and covered the rest with earth. It is by far the most important discovery that has yet been made. He has placed them under my charge, and given me the direction of the workmen, as he is obliged to go to Mossul to make preparations for the removal of the two finest colossal lions that have yet been discovered, which will, I trust, be on their way to England in a month or two. After that we shall cross the Zab with our tents, encamp there, and pass our time alternately in hunting and digging in the mound. You can have no idea of the difficulties Layard has had to contend with, or the energy, talent, perseverance, and shrewdness with which he surmounts them, or the exquisite tact and good humor with which he manages the different people he has to deal with. In the first place he has nothing but conjecture to guide him in his researches; it is literally groping in the dark, and all sorts of buried treasures may lie within his reach, while from the very small amount of funds placed at his disposal, he is unable to make anything like a proper search, and contents himself with sinking trenches almost at hazard as it were.

"*Jan.* 6.—Yesterday we removed more than thirty metal vases, bowls and saucers, most beautifully embossed and engraved, some shields and swords, of which the handles alone remain, the iron blades being decomposed, and a small marble vase. The cups and bowls and other ornaments are of some unknown alloy of metals, but they are all so encrusted with decomposed and crystallized copper, and so fragile, that they cannot be handled without great danger, and Mr. Layard is sending them home in the state in which he found them, without attempting to remove the rust. I spent eight hours yesterday in scratching them out of the clay with my hands, as the operation was too delicate to allow even a knife to be used. My wife was employed the whole night in packing them. We may now congratulate the British nation in being possessed of an entirely unique collection, the value of which is inestimable. The ornaments and sculptures on the vases denote a very advanced stage of civilization. Not the least curious of the discoveries are several hundred mother-o'-pearl studs, in form exactly resembling our shirt buttons.

6. *Oak Orchard Acid Spring Water, Alabama, Genesee Co., N. Y.*; by H. Erni, Assistant Chemist of the Yale Laboratory; and by Wm. J. Craw, of the same Laboratory.—This water is clear and transpa-

rent and without smell. It contained always a small sediment of organic matter, and tasted strongly acid, affecting the teeth; spec. grav. as found by Mr. Erni, 1·00482 at 15° C. 1000 pts. of the water yielded—

	Erni.	Craw.
$\dot{S}$	3·5706	3·532
Fe	0·2065	·2258
$\dot{A}l$	0·1111	·0966
Ca	0·4557	·4596
Mg	0·1562	·1805
K	0·0571	·0444
Na	0·0522	·0412
Na	.....	·0143
Cl	.....	·0220
$\dot{S}i$	0·0656	·0684
Chlorine and organic matters,	*traces*	....
	4·6750	4·6848

Representing the bases as combined with SO_3, we have for the composition of 1000 pts. of water—

	Erni.	Craw.
$\dot{S}$	2·0122	2·0070
Fe $\dot{S}$	0·4356	·4266
$\dot{A}l\,\dot{S}^3$	0·3702	·3232
Ca $\dot{S}$	1·1065	1·1161
Mg $\dot{S}$	0·4592	·5305
K $\dot{S}$	0·1061	·0822
Na $\dot{S}$	0·1196	·0945
Na Cl	.....	·0363
$\dot{S}i$	0·0656	·0684
Chlorine, organic matter,	*trace*	....
	4·6750	4·6848

Yale Laboratory, April 18, 1850.

7. *On the Cause of Auroræ Boreales;* by Auguste de la Rive, being an extract from a letter to M. Regnault, (Comptes Rendus, Oct. 15, 1849; Phil. Mag., xxxv, Dec., 1849.)—I have just read, in a memoir by M. Morlet on the Auroræ Boreales, inserted in the *Annales de Chimie et de Physique*, 3d series, vol xxvii, the following passage:—

"With regard to the origin of this luminous matter (that of the aurora borealis), it seems natural to attribute it to the electric fluid contained in the atmosphere, and which at great heights where the air is rarefied, must become luminous as under the receiver of the air-pump and in the barometric vacuum: this hypothesis would acquire a great probability if we succeeded in proving by direct experiments, that magnetism exerts an influence on electric light."

This last expression induces me to request you to have the goodness to communicate to the Academy of Sciences an experiment which I mentioned to you on my passage through Paris last June, and which you may perhaps remember; its object was to show, in support of the theory which I had advanced of the aurora borealis, the influence exerted by magnetism upon the light which is produced in ordinary elec-

tric discharges. Hitherto this influence has only been shown in the case of the luminous arc which escapes between two conducting points, each communicating with one of the poles of a voltaic battery; which is very different, both as concerns the phenomenon itself, and in what concerns its application to the theory of the aurora borealis. The following is my experiment.

I introduce into a glass globe about thirty centimetres in diameter, by one of the two tubulures with which it was furnished, a cylindrical iron bar, of such length that one of its extremities reaches nearly to the centre of the globe, whilst the other extends from three to four centimetres out of the tubulure. The bar is hermetically sealed in the tubulure, and covered throughout its length, except at its two ends, with an isolating and thick layer of wax. A copper ring surrounds the bar above the isolating layer in its internal part the nearest to the side of the globe; from this ring proceeds a conducting rod, which, carefully isolated, traverses the same tubulure as the iron bar, but without communicating with it, and terminates externally in a knob or hook. When by means of a stop-cock adjusted to the second tubulure of the globe, the air in it is rarefied up to three to five millimetres, the hook is made to communicate with one of the conductors of an electric machine, and the external extremity of the iron bar with the other, so that the two electricities unite in the interior of the globe, forming between the internal extremity of the iron bar and the copper ring which is at its base, a more or less regular fascicle of light. But if the external extremity of the iron bar is placed in contact with one of the poles of a strong electro-magnet, taking good care to preserve the isolation, the electric light takes a very different aspect. Instead of issuing, as before, from the different points of the surface of the terminal part of the iron bar, it is emitted only from the points which form the contour of this part, so as to constitute a continuous luminous ring. This is not all: this ring, and the luminous jets which emanate from it, have a continuous movement of rotation around the magnetized bar; one while in one direction, at other times in another, according to the electric discharges and the direction of the magnetization. Lastly, more brilliant jets appear to issue from this luminous circumference without being confounded with those which terminate on the ring, and form the fascicle. As soon as the magnetization ceases, the luminous phenomenon becomes again what it was previously, and what it is generally in the experiment known by the name of the *electrical egg*. Not having any powerful machine at my disposal, I used for my experiment an Armstrong's hydro-electric machine, the boiler of which I made to communicate with the copper ring, and the isolated conductor which receives the vapor with the iron bar, or *vice versa* when I wished to change the direction of the discharges. The experiment succeeded very well in this manner.

The experiment which I have just described appears to me to account very satisfactorily for what passes in the phenomenon of the aurora borealis; in fact, the light which results from the union of the two electricities in the part of the atmosphere which covers the polar regions, instead of remaining vaguely distributed, is carried by the action of the terrestrial magnetism round the magnetic pole of the globe, whence

it seems to rise in a revolving column, of which it is the base. We thus understand why the magnetic pole is always the apparent centre whence issues the light constituting the aurora borealis, or toward which it appears to converge. I shall not recur to the other circumstances which accompany this meteorological phenomenon, the agreement of which I have shown with the explanation I have given in a letter addressed to M. Arago, which was communicated to the Academy, and inserted in the Philosophical Magazine for April, 1849, p. 286.

But, having referred to this letter, in which the question was also raised respecting the explanation of the diurnal variations of the magnetic needle, permit me to add, that I have had occasion to prove, in England, both by my own observations, and still better by the more extensive ones of several physicists,* the existence of electric currents having a direction from the northwest to the southeast on the surface of the earth. The presence of these currents can be easily proved by means of the metallic wires which serve as telegraphic communications: wires which are placed underground and at the same time well isolated, except at their two extremities which dip into the ground, are best suited for this kind of observations. It is very curious to follow the agreement which exists between the variations of intensity of these currents and the variations of magnitude of the deviation of the magnetic needle of declination; a new proof to add to that drawn from their direction, that they are the cause of the diurnal variations.

Colonel Sabine has stated, in opposition to my explanation of the diurnal variations, an objection drawn from the observation on these variations at the Island of St. Helena and at the Cape of Good Hope.† I do not think it well founded, and, without entering into the details which will better find a place elsewhere, I shall limit myself to one single remark. I attribute the origin of the currents which give rise to the aurora borealis and to the diurnal variations, to the rupture of the electric equilibrium occasioned, in each atmospheric column, by the difference of temperature which exists between its base which reposes on the surface of the globe and its upper part which is at the limit of the atmosphere. Each column thus forms a kind of pile charged at its two extremities with contrary electricities, which unite in part by the pile itself, in part by a circuit formed of the upper regions of the atmosphere, of the atmospheric polar regions, and of the surface of the earth. Meteorological circumstances determine the greater or less proportion of the two electricities which unite by one or the other of these ways.

Now, the temperature of the base of the column must vary not only with the season, with the time of the day, and with the latitude of the place where it is observed, but also with the nature of the surface of the globe on which it reposes. When, therefore, this surface is the sea, the hours of maxima and minima of temperature are not the same as when it is *terra firma*, all other circumstances being the same; it results necessarily that the hours of maxima and minima of intensity of the electric currents, and consequently of the diurnal variations to

* See the observations of W. H. Barlow on this subject, Phil. Mag., vol. xxxiv, p. 344.

† Phil. Mag., vol. xxxiv, p. 466.

which they give rise, must be equally different. Now, St. Helena and the Cape of Good Hope may be considered as places enveloped in atmospheric columns, which have almost their entire base resting on the sea and not on the land; thence the anomalies pointed out by Colonel Sabine are very easily explained, and, in particular, it is easily understood how there is no agreement, in direction, which must in every case be different, between the diurnal variations observed at the Cape of Good Hope and those observed at Algiers, which is equally distant from the equator, but to the north. An excellent paper by M. Aimé on terrestrial magnetism, inserted in the *Annales de Chimie et de Physique*, 3d series, vol. xvii, in which he discusses comparatively the observations made at St. Helena, the Cape, and Algiers, has singularly facilitated the explanation of the anomalies presented as objections by Mr. Sabine.

I, however, do not pretend that there does not exist any anomaly; my explanation is not more free than others from those which result from certain local and exceptional causes. I am not further from admitting that the currents of induction determined on the surface itself of the globe, by its rotation under the influence of its magnetic poles, cannot have any part in the phenomenon of the diurnal variations and aurora borealis, and account for the connection which these variations appear to have with the absolute direction both in declination, and in inclination of the magnetic needle, and with the absolute intensity of the terrestrial magnetism. But this subject would require, for elucidation, to be treated more at length than can be done in a letter; I shall therefore stop, and beg to refer those persons who may be interested in this question to a memoir which I am on the point of completing, and which will be published forthwith.

8. *Charleston Meeting of the American Association for the Advancement of Science.*—The semi-annual session of the American Association was held by appointment in Charleston, South Carolina, in the early part of March, and was attended quite as numerously as could have been expected. The season of the year, and the distance of a majority of members, made it impossible for a large concourse to be gathered. We have failed to procure a full list of the papers read at this meeting, no complete list having at a late date been received from the Secretaries. That the papers were numerous and of importance, we know from the testimony of those who were at the meeting. Dr. A. D. Bache presided at this meeting, and the greatest hospitality, public and private, was enjoyed both from the city and inhabitants. With a most commendable liberality, the City Council assumed all the expenses of the Association in publishing the volume of Reports of proceedings and papers at this meeting. This example so worthy of imitation, will we trust, be a precedent for the future reception of the Association. Such contributions are honorable to those who proffer them, just to the cause of science, and truly encouraging to the working men who sacrifice the hopes of accumulation to the sacred cause of truth for the general good.

The next annual meeting of the Association will be held at New Haven on the 19th of August next. The Local Committee will soon issue their circulars of invitation.

VI. Bibliography.

1. *Proceedings of the American Association for the Advancement of Science*, second meeting. Held at Cambridge, August, 1849. Boston, 1850. H. Flanders & Co. 8vo, pp. 459.—This volume is composed mainly from the reports made at the time and printed in the Boston Traveler, which have since been corrected by the several authors and are now issued under the sanction of the publishing committee. It is a volume of abstracts rather than one of full papers, although many of the shorter papers are given in full detail. The volume covers a wide range of subjects in all departments of science and evinces a high degree of activity in physical investigation, much greater probably than has existed at any former period of American history. Many of the most important articles it contains have already appeared in this Journal, and others will find their way into it.

2. *The Annual of Scientific Discovery, or Year Book of Facts in Science and Arts, &c.;* edited by David A. Wells (of the Lawrence Scientific School, Cambridge,) and George Bliss, Jr. Boston: Gould, Kendall and Lincoln. 1850. 12mo, pp. 392, with a portrait of Prof. Agassiz.—This annual is projected upon a comprehensive plan including the most important discoveries and improvements "in mechanics, useful arts, natural philosophy, chemistry, astronomy, meteorology, zöology, botany, mineralogy, geology, geography, antiquities, together with a list of recent scientific publications, a classified list of patents, obituaries of eminent scientific men, and an index of important papers in scientific journals and reports." This volume is properly a book of selections from the various scientific discoveries of the year past rather than a complete registry of them, and as such it is a work of great merit, and highly useful to the scientific as well as general reader. In a cursory examination of the volume we observe, however, errors and omissions in some departments which more care will in future avoid; and we would especially suggest more attention to American facts and researches, and the propriety of giving a fuller index of the articles in scientific journals and reports. There are numerous original and important memoirs published in the past year, in American publications, to which no allusion is made either in the index of articles or in the body of the work, a deficiency to which we should not allude were not the title so comprehensive as to be calculated to mislead scientific men abroad. We notice also several incorrect statements copied from the daily newspapers, e. g., those regarding the copper mines at Bristol and in Litchfield, in Connecticut. It is our wish to encourage a work in the main so excellent, by suggesting imperfections that may hereafter be avoided. We are glad to learn that a large edition of the book has already been exhausted.

3. *The Physical Atlas of Natural Phenomena;* for the use of Colleges, Academies and Families; by Alexander Keith Johnston, F.R.G.S., F.G.S., American edition, Lea & Blanchard, Philadelphia, containing 26 maps in 4to, with interleaved text.—This atlas is an encyclopædia of knowledge relating to the physical character and phenomena of our globe, presented in a series of maps, with full descrip-

tions and a vast amount of added detail in the accompanying pages of letter press. The maps have been prepared with the skill and knowledge which none but the most extensive learning could command, and are so displayed by the use of colors and various designs as to speak decisively and intelligibly to the eye. The subject of geology is first presented, and the distribution over the earth of rock formations, including volcanoes, is seen in a general manner on Pl. 1. An elegant geological map of the British Isles is added. Another map or plate shows the distribution of mountain ranges, their exact courses and relations. The accompanying text treats of the mean heights and features of continents, highest peaks and general characters of chains. Another map is devoted to the Andes and Rocky Mountains with the ranges of America. Plate 4, illustrates in a very perfect manner the glacier system of the Alps; plate 5, very minutely and elegantly the distribution of volcanoes of the globe, and volcanoes and earthquakes are the subject of much important information in the text. In the same manner, there are several maps representing the distribution of the waters of the globe, their currents, temperature, tides, usual tracks of vessels, continental waters, river basins; others exhibiting the regions of rains, of deserts, the courses of winds and prevalent hurricanes; others, the vegetation, forest regions, distribution of plants and animals, and of races of men.

4. *Lake Superior, its Physical Character, Vegetation and Animals, compared with those of other and similar Regions;* by Louis Agassiz, with a narrative of the Tour, by J. Elliot Cabot, and contributions by other scientific gentlemen, with appropriate illustrations; pp. 428, 8vo. Boston: Gould, Kendall & Lincoln. 1850.

The narrative occupies 133 pages, and is drawn up with perspicuity, condensation and elegance; interspersed among the pages of the text are scientific remarks by Prof. Agassiz, on the various objects which presented themselves in the progress of the tour which was included between the 15th of June, and the 25th of August, 1848. Railroads and steamboats brought them speedily to and from the scene of action, and the seventy-one days were most industriously and successfully employed by the naturalists and pupils and amateurs in a party of sixteen, acting intelligently and vigorously under their distinguished and accomplished leader.

The most important scientific observations are given separately in an appendix to the narrative, and are included under the following heads.

Lake Superior—Physical character, Vegetation and Animals, compared with those of other and similar regions.

I. The northern vegetation compared with that of the Jura and the Alps.

II. Observations on the vegetation of the northern shores of Lake Superior.

III. Classifications of animals from Embryonic and Palæozoic data.

IV. General remarks upon the Coleoptera of Lake Superior, by Dr. John L. Le Conte.

V. Catalogue of Shells, with descriptions of new species, by Dr. A. A. Gould.

VI. Fishes of Lake Superior compared with those of the other great Canadian Lakes.

VII. Description of some new species of Reptiles from the region of Lake Superior.

VIII. Report on the Birds collected and observed at Lake Superior, by J. E. Cabot.

IX. Description of some species of Lepidoptera from the northern shores of Lake Superior, by Dr. Thaddeus William Harris.

X. The Erratic Phenomena about Lake Superior.

XI. The outlines of Lake Superior.

XII. Geological relations of the various Copper deposits of Lake Superior.

5. *A natural Scale of Heights by the application of which the Measures of different countries are reduced to a common measure known to all Geographers*, constructed by Miss COLTHURST.—Presented to the Royal Geographical Society, by G. B. GREENOUGH, V. P., [and by him forwarded to us.]—The standard is an equatorial, geographical mile, a fixed quantity universally known and derived from the figure of the earth =6086·78 English feet. Five of these miles being divided each into 100 parts or degrees, give a scale of 500 degrees each of which is equal to 60⅞ English feet.

The measures of different countries are arranged separately in parallel vertical columns, each with its own caption; and adjoining each on the left, is the scale derived from the centesimal division of the geographical miles, and the corresponding numbers or lines denote the values of the different measures.

6. *The East; Sketches of Travel in Egypt and the Holy Land;* by the Rev. J. A. SPENCER, M.A. *With illustrations from original drawings.* G. P. Putnam, New York. pp. 503, 8vo, in cloth, gilt. 1850.—As the physical features of these countries form a prominent topic in this agreeable and instructive volume of travels, it may be properly mentioned in this Journal. It follows with advantage after the more elaborate works from which it quotes and sometimes dissents. Its moral tendency is excellent, although its amiable author in his winding up has often viewed objects through a colored medium, and his numerous apologies seem to us uncalled for. We have derived both pleasure and useful information from the perusal, and can cordially commend it.

7. *Man Primeval, or the Constitution and Primitive condition of the human being, &c.;* by JOHN HARRIS, D.D., President of Cheshunt College, England. Reprint by Gould, Kendall and Lincoln, Boston, pp. 480, cloth. 1850.—Although this new work of Dr. Harris is a contribution to theological science, it has like its predecessor, "The Pre-adamite Earth," by the same author, such intimate relations to geology, and like that work, it presents such enlarged and just views of science, that it is entitled to respectful mention in this Journal.

8. *A Systematic Treatise, Historical, Etiological and Practical, on the Principal diseases of the Interior valley of North America; as they appear in the Caucasian, African, Indian and Esquimaux varieties of its Population;* by DANIEL DRAKE, M.D. 878 pp. 8vo: Cincinnati, Ohio, 1850. Winthrop B. Smith & Co., Publishers, Philadelphia.—This very elaborate work treats first, of General Etiology, pp. 701; and secondly, of the Febrile diseases of the region, pp. 703–863. In Book I,

there are chapters on the topography, hydrography, and geological outline of the great western valley; on the hydrographical basin of the Gulf of Mexico, its currents, tides, temperature, &c.; on the special medical topography of places along the coasts of the Gulf of Mexico; the delta of the Mississippi, and river above, with the regions east and west of the river, and the basin of the Ohio, Alleghany and other tributary streams, the basins of the St. Lawrence and Great Lakes, and the Hudson and Arctic hydrographical basins. Next the author treats at length of the temperature of the different basins, barometrical character, winds, rain, electrical phenomena, and whatever can have a bearing upon health. He then passes to the subject of population, its distribution and character, modes of life, diet, use of alcohol and tobacco, clothing, occupations or pursuits. Book second contains full descriptions of the various diseases, as to their many forms and symptoms and modes of treatment.

Dr. Drake is undoubtedly the most able man in America for so difficult a task. It is well known, he has for many years investigated the subject with characteristic ardor, and in the research has personally visited all parts of the West and South, making at many places anxious and laborious observations—medical, statistical and physical.

9. *Transactions of the Society of Arts for* 1846–7 *and* 1847–8. 1847, 1849.—The Society of Arts commenced in 1847, a new series of their publications, and have issued Parts 1 and 2 of the first volume. These transactions are elegant in style of typography and illustration, abounding in colored plates of great interest and beauty, and the memoirs are valuable contributions to the Arts. They treat of carving, cameo making, steam boilers and locomotives, atmospheric electricity, of beauty, artificial lava for ornaments, ancient Greek vases, steam navigation, lighthouses and beacons, lithography, ancient and modern bookbinding, photography, cotton of Honduras, and various other subjects of general interest.

10. *A Universal Formulary, containing the method of preparing and administering officinal and other Medicines, the whole adapted to Physicians and Pharmaceutists;* by R. Egglesfeld Griffith, M.D., 568 pp., 8vo, Philadelphia. Lea & Blanchard.—The Universal Formulary of Prof. Griffith has the completeness which its title implies, and is exceedingly convenient in arrangement. The body of the work is preceded by a long introduction containing comparative tables of weights and measures, United States and foreign, explanations of abbreviations and terms in use, with observations on the management of the sick room, and rules for the administration of medicines. The formulary is arranged alphabetically, according to the pharmaceutic names adopted in the United States pharmacopeia; the English appellations of articles are used, and the quantities are expressed in words instead of pharmaceutical signs. Copious indexes are added not only of the formulas, but of the diseases for which they are advised.

T. A. Conrad: Descriptions of one new Cretaceous and seven new Eocene Fossils from Georgia.—By T. A. Conrad, from the Journal of the Acad. Nat. Sci., Philad., [2], ii, part 1, p. 39. March, 1850. 7 species are Echinoderms and the rest Mollusca.

C. B. Adams: Monograph of Vitrinella, a new genus of Turbinidæ, with new species; by C. B. Adams. 10 pp. 8vo. Amherst, Mass. [Generic description, "Testa, turbiniformi, minimâ, vitreâ; aperturâ maximâ, orbiculari, subtus valde indentatâ vel umbilicata."—Distinguished by the vitreous texture of the shell, and the rapid enlargement of the whorls, producing a large aperture. Species from Jamaica.]

C. B. Adams: Contributions to Conchology, Nos. 5 and 6. 32 pp. 8vo. Amherst. —No. 5 contains new marine and terrestrial shells from Jamaica. No. 6, a memoir on the origin of the terrestrial molluscs of Jamaica; together with a description of a new genus of Helicidæ, *Spiraxis;* and notes on certain species of the land shells of Jamaica and descriptions of supposed new species.—[Genus Spiraxis is described as follows: "G. t. parvâ, turritâ; columellâ medio in laminam spiralem productâ: aperturâ ovali, medio partim divisâ: labro simplice." The *Achatina aberrans* of Pfeiffer is supposed to be identical with the author's Spiraxis aberrans.]

John W. Herschel: A Manual of Scientific Enquiry, prepared for the use of her Majesty's Navy, and adapted for travelers in general; published by the Lords Commissioners of the Admiralty; 488 pp. 12mo. *London*, 1849.

W. Baird, M.D., F.L.S.: The Natural History of British Entomostraca. 364 pp. 8vo, with 36 lithographed plates; published by the Ray Society.

A Sketch of the Medical Botany of South Carolina; being a Report made to the American Medical Association at its Sessions in Baltimore and Boston; by Fran. Peyre Porcher, M.D. (From the Trans. of the Amer. Med. Assoc., vol. II.) Philadelphia, 1849.

S. Chase, Prof. Math. Dart. Coll.: A Treatise on Algebra, 336 pp. 12mo. *New York*, 1849; D. Appleton & Co.

The Astronomical Journal. Nos. 5, 6. March.—These numbers contain—Development of the Perturbative Function of Planetary Motion, by B. Peirce, continued. —Observations of Astræa for 1847, by Prof. S. Hubbard.—On unlimited Spherical Triangles and their solution, by Wm. Chauvenet.—Ephemeris of Neptune; S. C. Walker.—Observations of Astræ, by Mr. James Ferguson.

Proceedings of the Boston Soc. Nat. Hist. MAY, 1849.—p. 150. On Algerite, a new mineral; *Dr. Bacon.*—p. 151. New shells of the U. S. Exploring Expedition (genera Buccinum and Nassa); *A. A. Gould.* JUNE.—p. 158. On the embryonic development of Campanularia; *Desor.* JULY.—p. 163. Description of Percopsis pellucida, a new fish; *Z. Thompson.* AUGUST.—p. 166. On the epithelial tissues; *W. J. Burnett.*—p. 168. Animalcules in blood; *Burnett.*—New shells of the Exploring Expedition (genera Columbella, Mitra, Conus); *A. A. Gould.* SEPTEMBER.—p. 172. On the Esox lucius of Richardson; *Ayres.*—p. 175. A new species of Helix, (H. exigua), found near Boston; *Stimpson.* OCTOBER.—p. 178. On two malformed skulls of the Cod; *J. Wyman.*—p. 179. On the Cranium of the Troglodytes gorilla; *J. Wyman.* —p. 181. New species of fish of the genus Polypterus, from West Africa; *Ayres.*—p. 182. Tooth of Troglodytes gorilla; *J. Wyman.*—p. 182. Scratched rocks of the coast of Labrador; *J. Wyman.*—p. 183. On the genus Cottus; *Girard.* NOVEMBER.—p. 190. On some peculiarities of Annelids; *Agassiz.*—p. 191. On four new species of Doris; *Agassiz.*—p. 192. Skulls of female Eel; *Ayres.*—Cranium of a Manatee; *J. Wyman.*

Proceedings of the American Philosophical Society, v, No. 44. Oct., March, 1850.—p. 108. Observations on the radiation of heat by air; *Henry.*—p. 117. On the alleged influence of the moon on the weather; *T. Gilpin.*—p. 125. Remarks on a memoir by Delgado on the disc of the Emperor Theodosius, presented to the Society by the Royal Academy of Madrid; *Trego.*—p. 127. On the original purchase of land in Pennsylvania and the celebrated "Indian Walk;" *Trego.*—p. 139. Observations on the occultation of Jupiter and his Satellites, Feb. 26, 1850; *Kendall.*

Proceedings of the Academy of Natural Sciences of Philadelphia, 1849, No. xii, vol. iv.—p. 146. Letter on the "Snow-bug."—p. 247. An article on two species of Distoma, by J. Leidy, read and to appear in the Journal.—p. 248. An article by Le Conte, on the Longicorn Coleoptera of the part of America north of Mexico, read, and to appear in the Journal.—p. 249. On new Entophyta; *J. Leidy.*—The number closes with different Reports relating to the Academy. *January, February*, 1850, Vol. v, No. I.—p. 5. Report on the Progress of Entomology in the United States during the year 1849; *S. S. Haldeman.*—p. 7, 8. On Entophytes; *J. Leidy.*—p. 10. New fresh-water Shells (received in exchange from the Australian Museum); *T. A. Conrad*, (10 species of the genera Unio, Paludina, Physa, Melania, Lymnæa).

Index photographed at the
beginning for the convenience
of the microfilm user.